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THE MAIN TREND OF THE SEVEN-YEAR PLAN

The Twenty-First Congress of the Communist Party of the Soviet Union pointed out that the decisive condition for the fulfillment of the Seven-Year Plan and the establishment of a material and technical basis for communism is an extensive adoption of new techniques, complex mechanization and automation of production.

The complex mechanization and automation of production processes constitute the basis for further technical progress in the national economy, for a new rise in productivity, for lowering the cost and improving the quality of products. These are the reasons why, in June, the Plenary Session of the Central Committee of the Communist Party of the Soviet Union considered the most important questions of technical progress in all branches of the national economy. The resolutions of the Plenary Session stress the main problem, the solution of which constitutes a guarantee for the successful completion of the Seven-Year Plan. The Seven-Year Plan envisages the elimination of arduous manual labor by way of completing the complex mechanization of production processes in industry, agriculture, the building industry, transport and municipal services. At the same time, it is planned to extend automation; this should radically improve working conditions and increase productivity.

Experience has shown that automation of technological processes in the iron and steel industry makes it possible to reduce the operating personnel by 25%, to increase the output by 10-15%, and reduce the cost of production by 20%.

Automation makes the work more accomplished and creative. It is of vital interest to a wide range of workers. Active creative endeavors of millions of innovators and leading industrial workers bear witness to the fact that every Soviet worker is fully aware of the great benefits of mechanization and automation.

The automation of production in a socialist society is not only of economic but also of great social significance. With the introduction of automation, the very character of productive work changes radically, the technical and cultural level of workers is raised, and all the necessary requisites for the elimination of the difference between intellectual and manual work are established. The work is reduced to the control of automatic machines and instruments, the adjustment of equipment, and the establishment of programs and regimes of technological processes.

At present the main operations in the iron and steel industry are mechanized and automated. But this is nowhere near all that has to be done.

In blast-furnace, open-hearth, and rolling-mill production it is now essential to change from the automation of separate operations and machines to a complex mechanization and full automation of metallurgical processes and to establishment of fully automated sections and, eventually, of fully automated shops. For this purpose, it is essential that serious consideration be given to the mechanization and automation of auxiliary processes.

In fact, at metallurgical establishments the main focus has so far been on the automation of basic units. The automation and mechanization of auxiliary sections, on the other hand, is not as advanced. At the same time, only a relatively small number of workers is engaged at the main units while the majority of the personnel is engaged on auxiliary operations. Reports have already been published that at the rolling-mill of the Magnitogorsk Metallurgical Combine – a leading industrial establishment – the operations on making, sorting and finishing the steel are not mechanized and almost half the total number of workers are engaged on these operations.

A further development of complex mechanization of separate technological operations is impossible without a radical modernization of the facilities for mechanization. It is necessary to improve the mechanical and machining facilities of the works, to improve its equipment, to expand design departments so that iron and steel works can be in a position to solve the problems of mechanization quickly on their own.

An active part in the introduction of new techniques and of the complex mechanization and automation of industrial processes is to be played by inventors and innovators who devote all their efforts and creative ideas in order to make the work easier, to improve working conditions and to increase the efficiency of metallurgical machinery. It is essential that at works, shops and separate sections the innovators and inventors are given real assistance and provided with all the facilities for speedy tests and the adoption of suggestions put forward, as well as to arrange for the award of inventors prizes. At establishments, shops and separate sections, teams of inventors and innovators should be organized so that they will be able to solve involved technical problems.

The Soviet metallurgists greeted the news of the convening of the Plenary Session of the Central Committee of the Communist Party of the Soviet Union in June this year with great enthusiasm. The socialist competition for the best performance on the occasion of the Plenary Session went ahead with a new impetus at all establishments of the iron and steel industry. Preliminary results of this competition and the first biannual report on the production in the first half-year of the first year of the Seven-Year Plan show that the metallurgists as well as all Soviet people will spare no effort in order to fulfill the program of industrial development ahead of schedule.

The major part of the competition on the occasion of the Plenary Session of the Central Committee of the Communist Party of the Soviet Union in June was the adoption of new techniques, complex mechanization and automation.

New units were put into operation ahead of schedule at several works and new technological processes have been developed: New large-capacity open-hearth and electric furnaces, automated rolling mills, equipment for electromagnetic mixing, machines for continuous casting of steel, equipment for the preliminary treatment of pig-iron; this is far from a full list of the technical modernization of the iron and steel industry.

All this shows that Soviet metallurgists are in the forefront of the fight for technical progress. Inspired by the resolutions of the June Plenary Session of the Central Committee of the Communist Party of the Soviet Union, they are working on a more extensive introduction of modern methods with an even greater effort.

The great goal – building a Communist society – inspires Soviet people with new creative energy and initiative, and with a sincere desire to put all their effort and knowledge at the service of the motherland.

* * *

KEEPING UP WITH THE "TEAMS OF COMMUNIST LABOR"

On July 19, 1959, Soviet metallurgists, inspired by the resolutions of the Twenty-First Congress of the Communist Party of the Soviet Union, will celebrate their Festival – Metallurgist's Day – in an atmosphere of new productive enthusiasm.

The workers of the metallurgical industry will mark this occasion with new successes in productivity. Their response to the care of the Party and Government are the tens of thousands of tons of pig iron, steel, and rolled section produced over and above the planned quota. In all sections of the metallurgical industry, an intense effort is being made to exceed the planned quotas, to reduce the cost of production, and to improve the quality of the products. Blast-furnace operators, steel melters, and rolling mill operators are making every effort to complete the plan of the first year of the Seven-Year Plan ahead of schedule.

The socialist competition is spreading and new forms of competition are being introduced at factories, shops, and separate sections.

The movement of the Teams of Communist Labor came into being before the Twenty-First Congress of the Communist Part of the Soviet Union which showed the Soviet people remarkable prospects of establishing the material and technical bases for Communism. The blast-furnace workers at the Magnitogorsk Combine and the steel melters at the Nizhne-Tagil Combine were first among the iron and steel workers to start a competition for the right to take the name of the Team of Communist Labor. In a short time this movement spread to all the iron and steel works throughout our country. Hundreds and thousands of iron and steel workers compete for the high honor of being a member of a Team of Communist Labor, and they continuously increase the output of plants by adopting new techniques and advanced methods, by improving their industrial knowledge, general education, and culture. Several groups have already been honored with the title of the Team of Communism Labor.

The Teams of Communist Labor are not comprised of extraordinary people. These are ordinary Soviet workers inspired by the desire to work and live like Communists. By their labor they educate themselves and erase their old attitudes from their minds.

The personnel of the Komsomol-Youth blast furnace at the Magnitogorsk Metallurgical Combine were awarded the title of the Team of Communist Labor and achieved the highest ratio in the world of daily output to working volume of the blast furnace and have considerably exeeded the productivity of the blast-furnace operators of the USA.

Teams at one of the open-hearth furnaces of the Nizhne-Tagil Metallurgical Combine, led by steel melters Kal'nichenko, Ploskonenko, Zashlyapin, and Obraztsov, have achieved the high honor of the Team of Communist Labor and have undertaken the obligation to attain in 1963 the level of production planned for 1965, to reduce the amount of defective product by at least half, to save raw materials and fuel continuously, to introduce advanced techniques, and to raise the level of their general education and culture.

The example of this group was followed by the workers of all shops at the Combine. In May, 1959, 82 teams, 24 shifts, three units and the distillation plant of the coke and by-product plant joined the competition for the title of the Team of Communist Labor; 47 leading workers competed for the title of Communist Shock Worker. In the course of a general public review of productive reserves, the Combine received 2149 suggestions which were

integrated into complex plans for increasing the efficiency of production units and improving the technical and economic productivity indices.

"Communism, as compared with capitalism, is a higher productivity of voluntary, class-conscious, and united workers utilizing advanced techniques. Communist subbotniks* are extremely valuable as the actual beginning of Communism. . . ." [1]. These works by the great leader of the working class, V. I. Lenin, written 40 years ago, are fully valid at the present time. One cannot help remembering these words when reading about the successes of the workers of the Dzerzhinskii Plant, one of the largest works in the South.

There, the title of the Team of Communist Labor was won by the team led by the senior blast-furnace attendant, a deputy to the Supreme Soviet of the USSR, P. P. Lygun. In four months of 1959, the team produced 928 tons of pig iron over and above the planned quota and attained a ratio of working volume of the blast furnace to daily output equal to 0.686. 5400 tons of coke and 2100 tons of limestone were saved; the cost of one ton of pig iron was reduced by 19 rubles, 85 kopecks. All the members of the team attended higher and secondary schools and took an active part in the social life of the shop and plant.

The team led by the senior steel melter, M. M. Lukashenko, was one of the first to be awarded the title of the Team of Communist Labor. These open-hearth furnace workers undertook to attain an output of 10 tons of steel per square meter of hearth area, to attain a service life of the furnace equal to 500 heats and to save 350,000 rubles by 1965. In four months of 1959, they produced 1485 tons of steel over and above the planned quota. The yield of steel from 1 m^2 of hearth area constituted 9.4 tons, and the idling periods for hot repairs were reduced by 0.7% relative to the scheduled time.

In February, 1959, the team of steel melter Mirgorogskii won the title of the Team of Communist Labor. The team undertook to produce 1250 tons of steel over and above the planned quota in 1959, to make only steel of the highest quality, to reduce the idling periods on hot repairs, to achieve a furnace life equal to 500 heats in 1959, and equal to 550 heats in the course of the Seven-Year Plan. The team is carrying out these obligations honorably.

The titles of the Team of Communist Labor at the "Élektrostal'" Plant were won by the groups led by steel melter A. V. Chizhov and forge-press operator P. I. Blokhin. A. V. Chizhov's team exceeded the production quota for the first quarter of the year by 4%, reduced defective material by 50% compared with 1958, and saved 23 kw-hr electric power for each ton of steel made. P. I. Blokhin's team exceeded the quota by 9.6% and reduced defective product tenfold in comparison with the previous year.

The efforts and thoughts of all Soviet people are now directed at a single goal: to fulfill to the best of their ability the great tasks set out by the Twenty-First Congress of the Communist Party of the Soviet Union. Every day brings new production victories. Having taken high obligations on themselves, the Soviet people are making every effort to fulfill and exceed these obligations. However, on the way to Communism it is necessary not only to increase production, but also to master the scientific and cultural achievements of Man.

The socialist competition is not limited to the Teams of Communist Labor. The initiative of the masses finds its expression in other forms too. But, whatever the form, the competition constitutes a remarkable school for Communist Labor, a school for educating the man of the future, and it is a great force in the fight for building our Communist society.

LITERATURE CITED

1. V. I. Lenin, Works [in Russian], Vol. 29, p. 394.

* Labor given voluntarily to the state on days off.

* * *

THE TEMPERATURE OF PIG IRON AND SLAG DURING THE PRODUCTION OF CONVERSION PIG IRON AT THE MAGNITOGORSK METALLURGICAL COMBINE

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The study of the thermal and temperature regimes of the operation of the blast-furnace hearth is of great theoretical and practical importance. For instance, the chemical composition of pig iron depends not only on the composition of the slag but also on the hearth temperature, the distribution of which affects the desulfurization power of the slag. The magnitude of the fluctuations of the temperature of pig iron and slag in the course of tapping and between separate tappings constitutes an index of the steadiness of the operation of the blast furnace.

In 1958 at the Magnitogorsk Combine, a large number of measurements of the temperature of the upper slag and of pig iron were carried out during the tapping of the blast furnace.* The temperature of the pig iron and slag was measured by means of platinum-platinorhodium immersion thermocouples with electrodes 2-2.5 m long (Fig. 1); the electrodes were insulated from each other by porcelain tubing, and over the length of about 100 mm from the junction by two-channel corundum tubing.

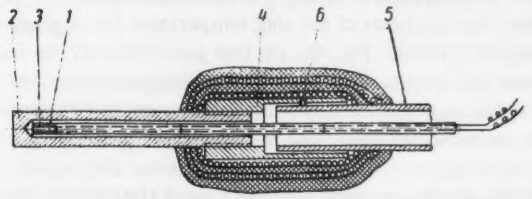

Fig. 1. Thermocouple for measuring the temperature of pig iron and slag: 1) Hot junction; 2) molybdenum sheath; 3) sleeve; 4) coupling; 5) protective tube; 6) set screw.

The thermocouple with the compensating leads was placed in an iron tube, ½ inch in diameter and 3.5-4 m long.

During the measurements of slag temperature the junction of the thermocouple was protected by a molybdenum sheath machined from the molybdenum rod and screwed into an iron coupling fixed to the tube by a set screw. The junction was insulated from molybdenum by a porcelain sleeve. The coupling and the end of the protective tubing was covered with asbestos rope and coated with 2-3 layers of fire clay mixed with pure sand.

The thermocouple for measuring the temperature of pig iron differed from the thermocouple described above in that instead of the molybdenum sheath it had a quartz cap, 7-8 mm in diameter and 100 mm long. The thermocouple was placed between the tap hole and the trough.

The temperature measurements were made in the course of four periods of furnace operation (Table 1). The temperature of the pig iron during the first and second periods was measured three times for each tapping during a period of twenty days: the temperature during the tapping was measured at the moment when the first, second and the third ladle were half full. Sometimes, the temperature of the pig iron was measured continuously during the tapping and the readings were recorded by a recording potentiometer.

The temperature of the upper slag was measured, in most cases, twice when the slag was flushed through the first cinder notch and twice when it was flushed through the second notch.

TABLE 1

Temperature of Pig Iron and Slag for Various Periods

Periods (1958)	Temperature of the upper slag for separate ladles, °C					Temperature of the pig iron for separate ladles, °C				Temperature difference, °C
	1	2	3	4	mean	1	2	3	mean	
14—22 May	—	—	—	—	1531	—	—	—	1478	53
23—31 May	—	—	—	—	1526	—	—	—	1473	53
4 November										
1 December	1519	1525	1530	1533	1527	1490	1498	1504	1497	30
2—27 December	1519	1526	1533	1537	1529	1477	1486	1490	1485	44

* Apart from the authors of this article the following engineers took part in this work: Yu. I. Borysov, L. A. Lepikhin, N. M. Korchkov, and technician A. A. Agashin.

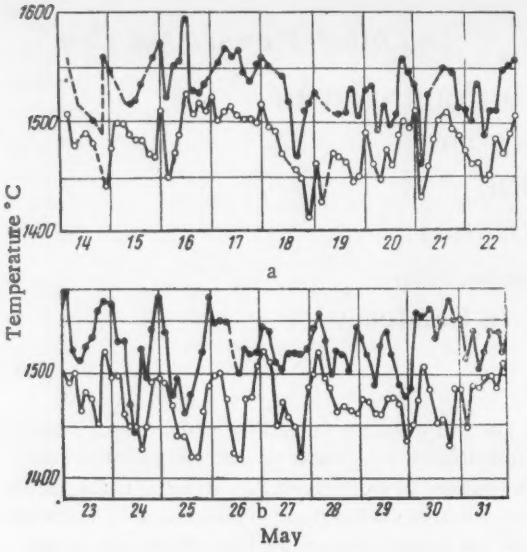

Fig. 2. Temperature curves for pig iron (top) and slag (bottom): a) during the first period; b) during the second period.

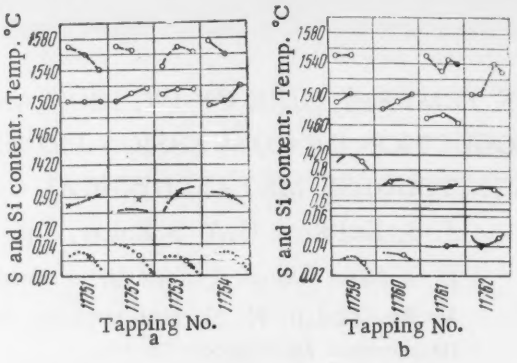

Fig. 3. Temperature of the pig iron and slag and the content of sulfur and silicon in the pig iron during the tapping: a) during normal furnace operation; b) during an irregular furnace operation; – – – slag temperature; ——— pig iron temperature; –·–·–· silicon content; ····· sulfur content.

During the third and fourth periods, the temperature of pig iron and of upper slag was measured in the course of 45 days during two tappings in every twenty four hours by the same method, the only difference being that the measurements were made in the iron trough near the pouring spout. To determine the difference between the temperature of the pig iron at the tap hole and at the pouring spout, several test measurements were carried out and it was established that the temperature of the pig iron in the spout was 10°C lower than at the tapping hole.

The fluctuations of the mean temperature of the upper slag and the pig iron for separate tappings during the first two periods are shown in Fig. 2 from which it is seen that as a rule the maxima and minima of temperature curves for pig iron and slag coincide. For the third and the fourth period, Table 1 shows the mean temperature for each ladle in addition to the over-all mean temperature for the tapping.

The first and the fourth periods were taken as test periods. The furnace was operated according to the usual slag regime at the Magnitogorsk Metallurgical Combine (8.3-8.6% MgO in the slag). During the second and the third periods the MgO content in the slag was increased to 10,8-11,3%.

The temperature fluctuation curves for the pig iron and slag in the course of tapping are shown in Fig. 3. The mean temperature difference during tapping for the upper slag and the pig iron does not, as a rule, fluctuate greatly during an even operation of the furnace. However, when the operation of the furnace becomes slightly irregular the fluctuations of the temperature of the upper slag increase; the temperature of the pig iron does not fluctuate as much. With a regular operation, the content of sulfur in the pig iron usually decreases in the course of the tapping, and the silicon content increases or remains constant but, as a rule, it is higher for a higher temperature.

If some irregularities occur in the furnace operation, the temperature difference of the upper slag and the pig iron usually decreases, and the differences between separate measurements of the slag temperature for a given tapping increase (Fig. 4). On that particular day the furnace was operating with the burnt-through monkey and the slag in the zone of the first cinder notch was intensely cooled with water. The maximum temperature difference between the slag from the first and the second cinder notches reached 110-140°C, and after tapping No. 11874 the first cinder notch could not be opened at all. Therefore, the difference in the temperature of the upper slag in the course of tapping is determined by the irregularities of the furnace operation as well as by the local cooling. Usually, the temperature fluctuation of pig iron and slag during the tapping depend on how even the operation of the blast furnace is; the more even the operation the smaller are the fluctuations. Table 2 contains the averaged (for separate periods) maximum fluctuations of temperatures for the upper slag and the pig iron for each tapping and between consecutive tappings. As a criterion of the steady operation of the furnace during the periods under comparison we took the average number of charge changes per day during the given period, because changing the manner of charging constitutes one of the methods for eliminating irregularities of furnace operation.

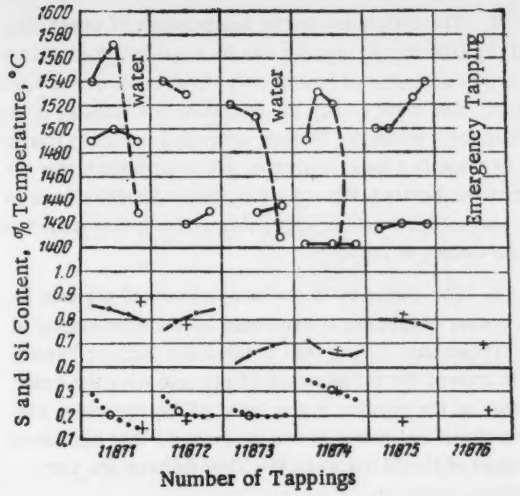

Fig. 4. Temperatures of the pig iron and slags and contents of silicon and sulfur during the operation when the monkey was burnt through (notation as in Fig. 3).

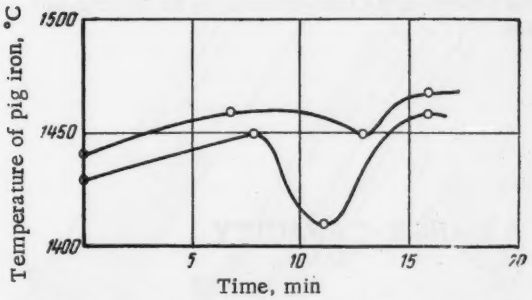

Fig. 5. Temperature of the pig iron in the course of tapping.

Direct observations of the furnace operation showed that out of four periods quoted in Table 2 the most even operation of the furnace was in the third period, and there was an irregular operation in the second. Of course, the number of charge changes does not always reflect the conditions of the furnace operation, and in this respect the choice of the number of charge changes as a criterion for the furnace operation is rather arbitrary.

Interesting data on the regularities of the temperature distribution in the course of pig iron tapping were obtained in the main by means of the continuous recording of the pig iron temperature during the whole period of tapping. It is seen from Fig. 5 that a minimum on the temperature curves occurs eight to fifteen minutes after the beginning of the tapping. It was noticed that the time when the minimum occurs coincides with the time when the runner is filled with the lower slag. The occurrence of the minimum at the time approximately half way through the pig iron tapping can be explained by the distribution of the temperature in the horizontal plane of the hearth. Numerour investigations of the temperature at the level of the

TABLE 2

Temperature Differences of the Pig Iron and Slag for Various Periods

Period	Average temperature difference, °C.				number of changes in the manner of changing
	upper slag		pig iron		
	during tapping	between tappings	during tapping	between tappings	
14—22 May	28	24	18	19	1.2
23—31 May	38	22	19	19.4	2.0
5—30 November . . .	23	15	12	10	1.1
2—27 December . . .	23	20	14	12	1.6
Average	28	20	16	15	

tuyeres showed that in a ring at a distance of 0.5-1 m from the furnace walls the temperature of the pig iron is the highest, and in the center of the furnace it is the lowest. A similar distribution of the temperature in the cross section of the furnace is, apparently, also maintained below the tuyeres.

The fact that this temperature distribution is maintained over a long time period (from one tapping to another and even during the tapping) indicates that there are no significant convective currents in the horizontal direction in the blast-furnace hearth.

The occurrence of the minimum in the pig iron temperature during tapping, which minimum coincides in time with the appearance of the lower slag, can also be explained by the fact that the slag near the walls of the hearth is at a lower temperature which is near the solidification temperature, and hence some pig iron which is in contact with this slag is cooled. A minimum in the temperature of the pig iron was found in the majority of cases when the temperature was continuously measured during the tapping. The temperature drop constituted 10-15°C. Considering the mixing and equalization of the pig iron temperature during the tapping, the actual temperature difference of pig iron in the hearth center and the peripheral hot ring was probably higher.

Experimental data which show the relationship between the silicon content and the temperature of the pig iron and slag are presented in Fig. 6. The scatter of the experimental points on the graph is explained by the fluctuations in the composition of the slag and to some extent by experimental errors in the analytical determinations. It is seen from the graph that the silicon content in the pig iron depends on the temperatures of the pig iron and of the slag. In addition, as is shown by the analysis of the pig iron from consecutive tappings, the silicon content in separate tappings changes less rapidly than the temperature of the pig iron. This can be apparently explained by the fact that in the hearth "well"

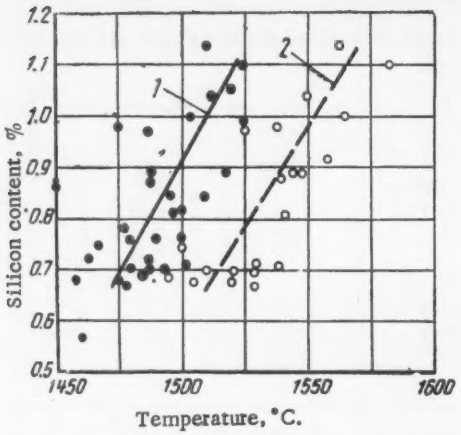

Fig. 6. Silicon content in the pig iron: 1) as a function of the pig iron temperature; 2) as a function of the slag temperature.

there is considerable quantity of pig iron which is gradually renewed.

From the results of this investigation one can draw the following conclusions.

1. The difference in the temperature of upper slag and pig iron during tapping can be regarded to a certain extent as an index of how evenly the furnace process takes place. The more steady the operation the smaller is the difference. When the furnace operation becomes irregular or there is a local source of low temperature (for instance the burning-through of coolers) the difference in the temperatures of the upper slag and pig iron increases in the course of tapping.

2. The variation in the temperature of pig iron in the course of tapping is explained by the distribution of the temperature of pig iron in the blast-furnace hearth. As is known, the temperature of pig iron over the cross section of the furnace at the level of the tuyeres is also nonuniform and hence it can be assumed that horizontal currents of liquid metal in the blast furnace are very limited.

3. The silicon content in pig iron depends on the temperature of pig iron and slag. However, no pronounced fluctuations in the silicon content were detected during the investigations. This is explained by the presence of large quantities of pig iron in the hearth "well". The sulfur content in pig iron decreases as the tapping proceeds.

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SOME MODIFICATIONS IN THE DESIGN OF A LARGE-CAPACITY BLAST FURNACE

V. S. Brazhnik and A. I. Shcherbina

Krivoi Rog Metallurgical Plant

On September 6, 1958, a large-capacity blast furnace was blown in at the Krivoi Rog Plant. It was built in accordance with the standard design developed by the Gipromez. When the furnace was accepted, the excellent features of the design were noted. In the opinion of the operating personnel, however, some problems have not been solved satisfactorily by the Gipromez and the machine-building works concerned. Some parts of the furnace have been modified by the Krivoi Rog Plant.

MODIFICATIONS OF THE STANDARD DESIGN

The lining plates of the receiving hopper of the charging equipment. According to the Gipromez design, the lining of the receiving hopper requires 87 different positions of the lining plates. To cast these plates one requires a large number of patterns, and, hence, the cost of plate production is considerable. In addition, because of the large number of plates, the repairs to the hopper become difficult.

We modified the design of the lining of the receiving hopper at our Plant by reducing the number of positions of the plates to 29 (Fig. 1). With the lining designed by Gipromez one could cast 1-6 plates with one pattern, but with the lining designed at our Plant one can cast 2-30 plates with one pattern.

The lining plates of the furnace dome according to the Gipromez design are to be made from cast iron and inlaid refractory brick material (Fig. 2a). This method does not provide a satisfactory protection and , under the conditions which obtain at the Krivoi Rog Plant, the plates crack and break after 6-8 months of operation; leakage holes appear in places where the welding of the bolts becomes damaged.

At our Plant we have made lining plates for the blast furnace cupola from steel 35L without a refractory inlay (Fig. 2b). The thickness of the plate without cleats and ribs is 60 mm, and the height of cleat is 105 mm.

Lining plates for the blast furnace top. In their design the Gipromez introduced lining plates of the "book-

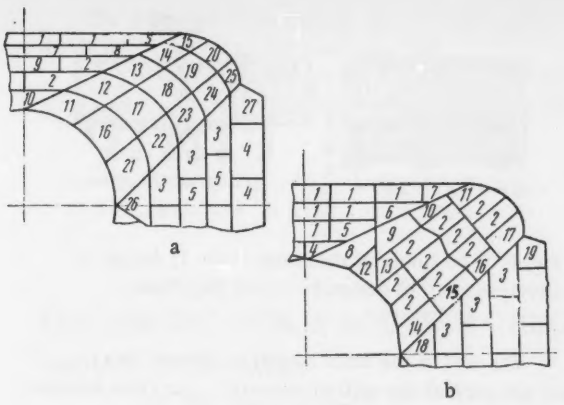

Fig. 1. The lining of the receiving hopper of the charging equipment: a) design by the Gipromez; b) design by the Krivoi Rog Plant.

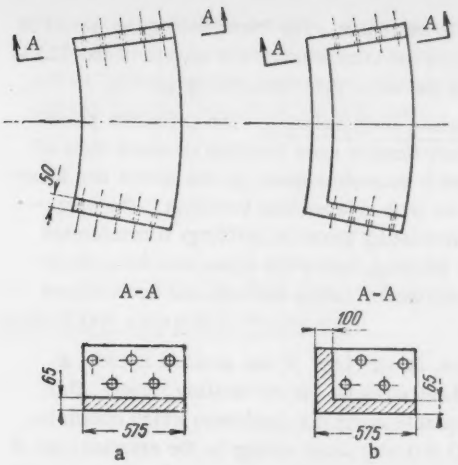

Fig. 3. Lining plates for the blast-furnace top: a) "bookcase" type; b) KMC type.

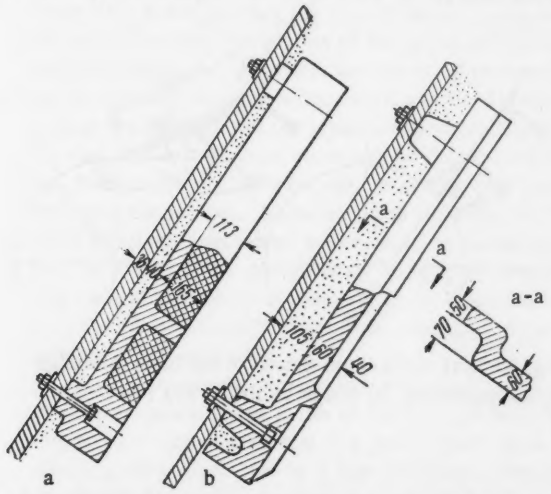

Fig. 2. Lining plates for the blast-furnace cupola: a) design by the Gipromez; b) design by the Krivoi Rog Plant.

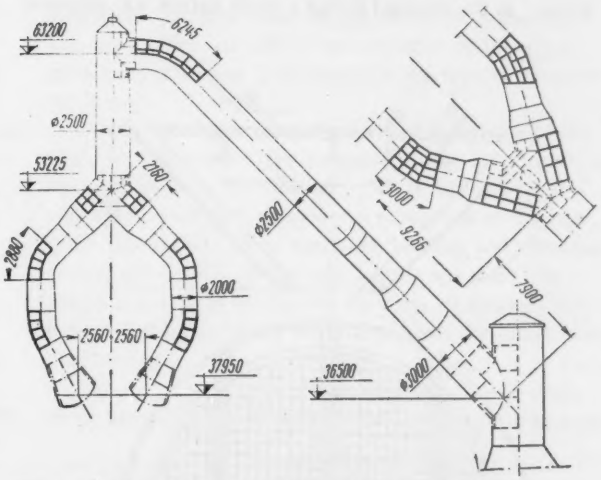

Fig. 4. Lining of the gas offtake and downcomer. Dotted lines indicate the plates designed by the Gipromez, thick lines indicate additional plates.

cases" type (Fig. 3a) for lining the blast furnace top and did not use lining plates of the KMC design (Fig. 3b) which were found to be very satisfactory in service in the existing blast furnaces of the Krivoi Rog Plant.

During the inspection of the top of the blast furnace which was repaired in 1957, it was found that the plates of the KMC design were in a satisfactory condition after four years operation. Therefore, it was decided that lining plates of the KMC-type should be used in the new blast furnace.

Lining of the gas offtake and downcomer. According to the Gipromez design, the gas flues are lined with steel plates only at junctions. The rest of the lining is made of fire brick.

Additional steel lining of the bends of the total weight of 56 tons (Fig. 4) was introduced by our Plant.

Dust catcher. The pug mills for the discharge of the dust from the dust catcher and for the humidification of the dust are designed in such a way that they can grind the brick material of the dust catcher lining if it accidentally enters the pug mill. However, the pug mills at the existing blast furnaces of the Krivoi Rog Plant frequently break down because of brick material entering the pug mills.

Repairs to the pug mill interrupt the discharge of the dust. Therefore, at our Plant a protective grate (Fig. 5), which consists of eight sections placed on H-beams welded to the dust catcher shell, has been installed in the lower part of the dust catcher. Where the beams are welded to the shell the lining bricks are removed.

Hot-blast valve mechanism. The mechanism for the forced closing of the hot-blast valves installed at the existing blast furnace stoves works continuously and smoothly

during a whole campaign. The Plant decided to install at the new furnace the same mechanism instead of the ÉZTM type in which the valve gate descends by gravity.

Blast-furnace stove building. The Gipromez project includes a blast-furnace stove building in which most of the equipment is accommodated. At the Krivoi Rog Plant there are stoves with and without buildings. The operation of the air-heating stoves in buildings is much more difficult, the building makes the repair and the replacement of the equipment rather difficult and accumulates gas and dust.

Therefore, at our Plant it was decided to erect a structure without walls for the air-heating stoves. This is quite acceptable under the conditions which obtain in the South. In this way some savings in the erection cost of the furnace were effected.

Blast-furnace working platform. The floor of the working platform around the furnace is made of cast-iron plates. In the standard design a brick surface was proposed.

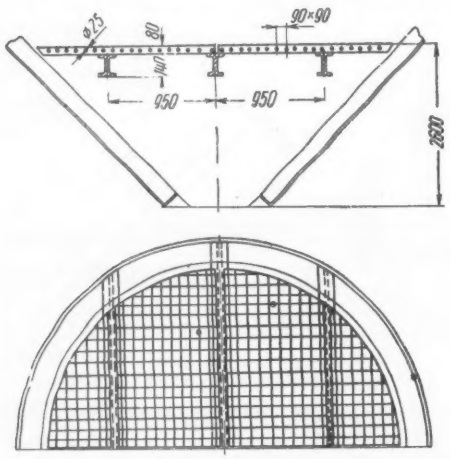

Fig. 5. Protective grate in the dust catcher.

MODIFICATION OF THE NONSTANDARD ITEMS OF THE BLAST-FURNACE UNIT DESIGNED BY THE UKRGIPROMEZ

The lining of the sinter bins. The experience of the Magnitogorsk Combine and some other Plants showed that rails make the most suitable material for the lining of bins for hot sinter. Therefore, to increase the durability and the service life of these bins, our Plant made the lining from old R-38 or R-43 railroad rails instead of fire brick. Openings for bolts for fixing blocks of rails were made in the reinforced concrete beams (Fig.6). There was no provision for bolts in the Ukrgipromez design, although, even when fire brick lining is used, the fixing of beams by welding at elevated temperature is unreliable.

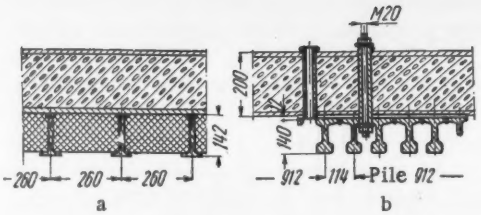

Fig. 6. The lining of the sinter bins: 1) design by Ukrgipromez; b) design by Krivoi Rog Plant.

The seal of the drum shutoff of the ore bins (Fig. 7) did not prevent the spill of material. Our Plant installed a seal of the drum shutoff of the Magnitogorsk Combine type. The seal consists of a 14 mm thick base plate which is attached to a support and an angle; special protective plates of high-manganese steel, 30 mm thick, are riveted to the base plate. Each drum has six protective plates.

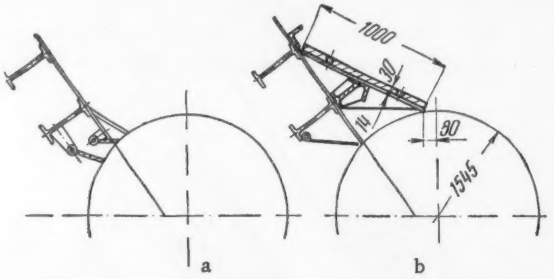

Fig. 7. Seal of the drum shutoff of the bins: a) design by Ukrgipromez; b) design by Krivoi Rog Plant.

Guide roller for the skip ropes. At the beginning of the operation of the blast furnace, it was found that at the turning point in the lower part of the skip the skip rope rubs over the rail supports. To prevent the wear of the rope the Plant installed guiding rollers.

In addition to the above modifications, the Plant also dispensed with the heating arrangement for the stockhouse since the sinter from the local sinter plant is supplied hot to the blast-furnace shop.

SUGGESTIONS FOR FURTHER IMPROVEMENTS

According to the original project, cold and hot air is mixed in the heat of the hot-blast duct.

To prevent damage to the refractory lining of the straight section of the hot-blast duct during rapid temperature changes it is desirable to introduce the cold air for mixing between the furnace and the air stove. Operational experience at one of the blast furnaces has shown that a satisfactory mixing is achieved in this way.

The discharge of air through the air relief valve should be directed into the waste-gas flue.

To provide normal conditions for carrying out tappings it is necessary to increase the length of the main runner. To avoid the overflow of pig iron over the electric cable conduit it is necessary to remove the supply cables from under the pig iron car track and place them outside the boundary of the casting house.

* * *

EQUIPMENT FOR A ROUTINE CHECK ON THE OPERATION OF BLAST FURNACES

B. M. Rakovskii

Central Laboratory of Automation

The existing instruments used at blast furnaces for controlling and regulating the blast-furnace process do not provide a complete picture of the course of the blast-furnace process and, therefore, the operating personnel has to evaluate the process from some additional factors such as the brightness of the tuyeres, the temperature of the slag, and other factors which can be determined visually. Such control methods are subjective and may lead to erroneous conclusions. Therefore, it is necessary to find some additional parameters which could be measured so that the course of the process could be fully evaluated. The Central Laboratory of Automation, in conjunction with the "Zaporozhstal'" Plant, is now working on the solution of this problem.

For measuring the temperature and sampling the gas at different points in the radius of the blast furnace, an intermittent-action apparatus of a probe type is used. The sampling tube is actuated by a rope mechanism through an electric hoist with asynchronous motor with a short-circuited rotor.

When the tube moves in the stock toward the center of the shaft it is subjected to a variable load due to friction and sticking in the stock so that the motor operates at an excessive overload and the tube is subjected to bending and vibrations. These phenomena are very undesirable since they may result in an extensive wear of the gland stuffing and the wear of the whole sampling mechanism.

When the tube jams and vibrates, the thermocouple, which is inserted in the tube for temperature measurements at various points along the radius of the blast-furnace shaft, cannot function satisfactorily. After a few measurements the hot junction of the thermocouple breaks off.

To reduce bending and vibrations of the sampling tube when it jams in the stock, an apparatus for stabilizing the drive of the electric hoist by means of pulling the front branch of its rope by a pneumatic device (Fig. 1) was proposed and installed at one of the blast furnaces of the "Zaporozhstal'" Plant.

The shock absorption is effected by means of a one-way servomotor of 1000 mm stroke and 200 mm piston diameter. The rope from the servomotor is connected through a system of pulleys to a movable pulley which pulls away the lower front branch of the rope of the electric hoist.

Tests have shown that the drive of the electric hoist works smoothly and without overload. The air pressure in the servomotor is 0.5-1 atmos. This is sufficient to ensure shock absorption and prevent elongation of the rope. When this apparatus was installed, bending and vibrations of the tube ceased. If the tube jams in the shaft, the servomotor acts as a buffer for the tube; it slackens the rope of the hoist slightly and thus protects the motor from overloading.

The automatic control system of the electric drive of the sampling tube includes a time relay with which the

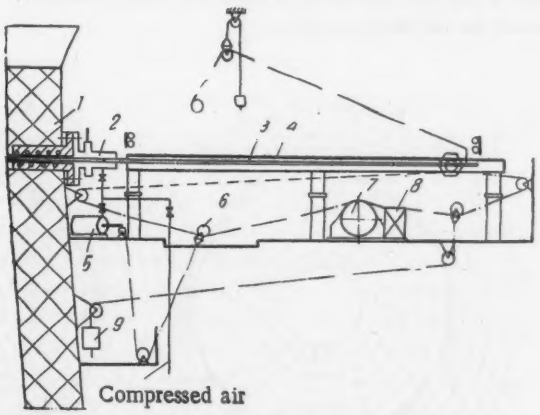

Fig. 1. Equipment for reducing bending and vibrations of the gas-sampling tube: 1) embrasure; 2) gland of the sampling tube; 3) tube; 4) guiding channels; 5) servomotor; 6) movable pulley; 7) hoist; 8) electric motor; 9) counterweight for pulling away the back branch of the rope.

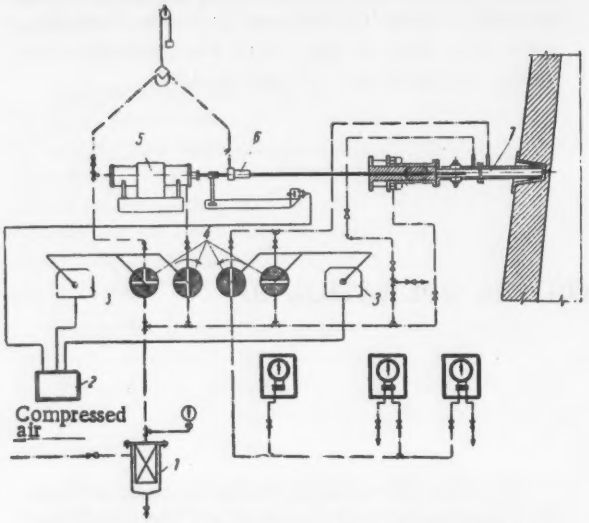

Fig. 2. Method of cleaning and blowing the tube for measurements of the static pressure of the gas: 1) air filter; 2) time relay; 3) servomechanisms; 4) stopcocks; 5) servomotor; 6) puncher; 7) sampling tube.

maximum time interval during which the tube remains in the charge and the time interval for cooling the tube between two samplings are preset. There is a device for the protection of the tube from bending when it is overloaded: if there is a danger of a permanent deformation of the tube the shaft of the servomotor actuates the switch for the return movement of the tube. The tube will then move forward only if the shock-absorber switch is opened.

For the automatic control and operation of the electric hoist in accordance with a preset program there is a system of probe starters consisting of a charge counter with a step-by-step switch, a time relay and a mercury switch for the thermocouples.

For temperature measurements there are eight thermocouples mounted at angles of 45° to each other around the blast-furnace top. Compressed air is supplied to the thermocouple sheaths to prevent the diffusion and deposition of soot.

For pressure-drop measurements in the blast furnace there is an attachment with a horizontally mounted embrasure flush with the lining brickwork (at 8.5 m below the stockline). The embrasure contains a sampling tube, 62 mm in diameter, which is cleaned from time to time by means of a 32 mm diameter pin connected to the PA-23 puncher and pneumatic servomotor with a piston of 160 mm diameter and 1500 mm stroke (Fig. 2).

The system of cleaning, blowing, and cutoff is operated by four one inch diameter stopcocks which are operated by servomechanisms and a separate time relay. The pin moves forward every thirty minutes and clears the sampling tube. If the tube is plugged the pin moves as far as is necessary to reach the opening.

To prevent the control lines from being plugged with dust, the gas pressure is measured by the method of continuous flow. Diagrams of the measurements of the static pressure and some pressure drops for 24 hours are shown in Fig. 3.

For continuous measurements of the thermal condition of the lower part of the blast furnace, a method for measuring the relative temperature at the tuyeres by means of PRK-600 radiation pyrometers is being developed. With the continuous measurement of the temperature at the tuyeres, it is possible to estimate the sign and the magnitude of the change in the heat content of the charge before the discharge of the liquid products from the blast furnace.

For the installation of radiation pyrometers at the tuyeres, a small-size protective equipment was developed. It consists of a water cooler, a nozzle for blowing off the hot blast by cold purified compressed air, a cutoff shutter,

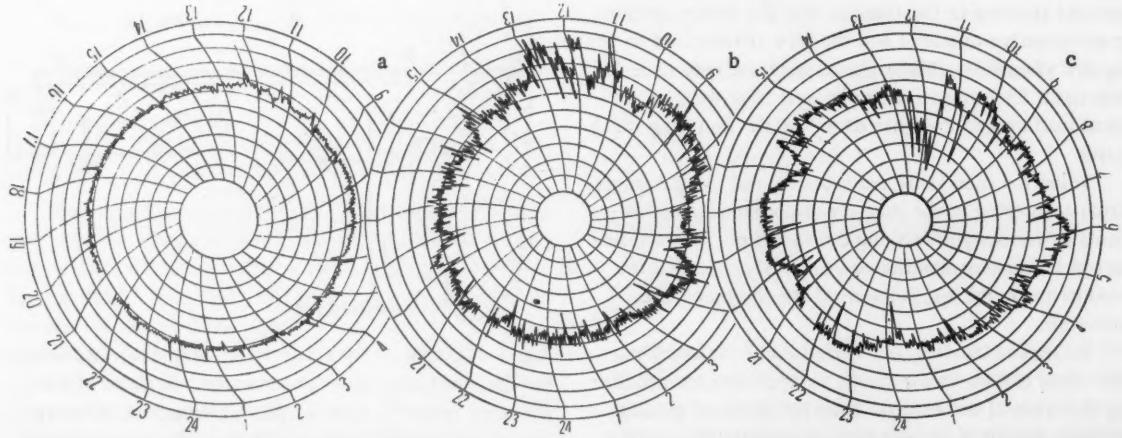

Fig. 3. Recordings of static pressure and the pressure drop through the furnace: a) static pressure; b) upper pressure drop; c) lower pressure drop.

and ball mountings for directing the pyrometer onto the bright spot of the tuyere. The vision angle of the pyrometer is 2° 36'. It would be expedient to investigate the possibility of connecting the pyrometers in parallel (to obtain the mean temperature of the tuyeres) as well as of using pyrometers of high response inertia. By averaging the temperature of the tuyeres, one is able to obtain a mean temperature which could be usefully compared with other objective measurements of the heat content of the furnace (e.g., the silicon content in pig iron, etc.).

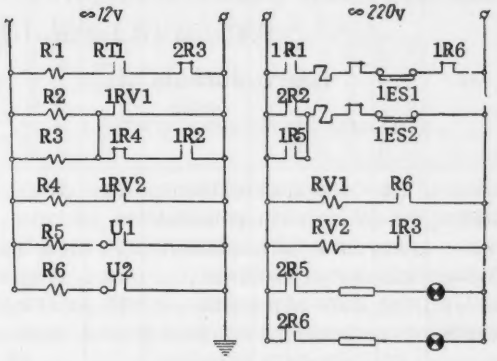

Fig. 4. Circuit for controlling the movement of the thermocouple for slag temperature measurements: RT – thermal relay; R1-R6 – relay; RV1 and RV2 – time relay; 1ES1 and 1ES2 – end switches.

For measurements of the temperature of the upper slag during flushing, a tungsten-molybdenum thermocouple (with 0.5% Al content in molybdenum) mounted above the slag runner in a protective tube with a slit for the pulse line, was tested. The hot junction was screened by a graphite block attached to the thermocouple by a bayonette joint.

For the automatic operation of the mechanism supporting the thermocouple a system of two-position control, with a correction for the position of the thermocouple depending on the level of the slag in the runner, was developed (Fig. 4). The thermal relay, RT, is directed on the spout of the first cinder ladle into which the slag is collected. When the slag appears in the spout the relay switches on the mechanism for lowering the thermocouple which descends until the contact pin, U2, touches the slag and the switches, 1R6, which are normally closed, are opened. The signal from the relay, R6, actuates the first time relay RV1; after a predetermined interval of time, during which the thermocouple remains in the slag, the switches, 2R2, are closed and the thermocouple is raised. The time relay, RV2, prevents the thermocouple from being lowered again; this could happen since the switches of the thermal relay remain closed until the runner cools down. The contact pins (graphite electrodes of 20-30 mm diameter) U1 and U2 serve for maintaining a preset distance between the thermocouple junction and the slag surface.

* * *

SELECTING THE TEMPERATURE OF STEEL FOR CASTING

Yu. G. Gurevich and O. F. Antropov

Zlatoust Metallurgical Plant

For several years at the Zlatoust Metallurgical Plant the temperature of liquid steel was measured by means of platinum-platinorhodium immersion thermocouples. By analyzing the results of these measurements with the use of known statistical methods it was possible to standardize the temperature of steel during tapping.

For each steel grade the mean and the most frequent temperatures, the mean and the mode and the standard deviation were determined statistically (Table 1). Sixfold value of the standard deviation was assumed as a guaranteed interval of temperature fluctuations which should be ensured by the whole technological process. The range of temperature fluctuations determined in this way was taken as the basis for establishing the permissible temperature fluctuations during pouring, to be specified in the technological instructions for a given steel grade.

The temperature of steel during tapping as measured by means of an immersion thermocouple during the productions of steels 40KhNMA, 18KhNVA, 30KhGSNA, 38KhMYuA, and ShKh15, is sufficiently uniform. The differences in the temperature of 1Kh18N9T steel indicate that the temperature regime for melting this steel has not been worked out satisfactorily. This fact was also confirmed by other operating statistics. This shortcoming was eliminated after a special investigation had been carried out.

The results of the statistical analysis also showed that the technological instructions should specify the range of the required temperatures within limits of 30-45°C depending on the steel grade. At the same time, the higher the content of the alloying elements in the steel the larger should be the temperature range specified in the instructions (see Table 1). These considerations were taken into account when the temperature of various steel grades at the time of tapping was established.

TABLE 1

Statistical Data on the Temperature of Liquid Steel

Steel grade	Number of measurements	Mean temperature, °C	Temperature, °C, most frequently occurring	Standard deviation	Range of temperature fluctuations
40KhNMA	165	1591	1592	6.70	40.20
18KhNVA	195	1590	1592	7.40	44.40
30KhGSNA	301	1587	1588	7.50	45.00
38KhMYuA	167	1591	1591	7.55	45.30
1Kh18N9T	200	1559	1563	11.93	71.58
ShKh15	123	1536	1539	5.21	31.20

TABLE 2

Recommended Temperature Limits of Liquid Steel in the Ladle

Steel grade	Number of heats studied	Recommended temperature limits for the steel in the ladle, °C	Steel grade	Number of heats studied	Recommended temperature limits of the steel in the ladle, °C
18KhNVA	195	1580-1620	Kh15N60	26	1520-1560
12KhN2A–12KhN3A	71	1580-1620	38KhMYuA-35KhMYuA	224	1550-1590
40KhNMA	165	1570-1610	2Kh13	47	1560-1600
30KhGSA	116	1570-1610	Kh12	38	1490-1530
30KhGSNA	301	1570-1610	Kh9S2	98	1530-1570
13N5A	32	1570-1610	ShKh15–ShKh15SG	224	1520-1550
EI94–EI256	63	1480-1520	ShKh6–ShKh9	157	1520-1550
1Kh18N9T	200	1570-1610	EI69	39	1520-1560

In the determination of the optimum temperature of steel during tapping by means of variance analysis and other statistical methods, the effect of the temperature of liquid steel in the ladle on the properties of steel were taken into account. For each steel, the effect of temperature during tapping on the defects to which the given steel was most susceptible was studied. Thus, for instance, for 1Kh18N9T steel the optimum temperature was established depending on the surface of the ingots and slabs; for 38KhMYuA steel – depending on the macrodefects; for ball-bearing steel – depending on the nonmetallic inclusions, etc.

The recommended temperatures of liquid steel in the ladle, as determined by the immersion thermocouple under the conditions which obtained in the electric steelmaking shop of the Zlatoust Metallurgical Plant, are shown in Table 2. By statistical analysis of the results from a large number of heats it was established that the temperature drop between the temperature of steel in the furnace before the tapping and in the ladle constituted 30-40°C.

By measuring the temperature of the steel and maintaining the temperature fluctuations within the limits shown in Table 2 it was possible to reduce the amount of rejected product significantly. However, because of inadequate supplies of platinum-platinorhodium wire for

thermocouples it was not possible to arrange for measuring the temperature several times during each heat, and hence the effectiveness of the application of the results obtained from this investigation cannot be fully realized.

* * *

IMPROVEMENTS IN THE METHOD OF SINTERING NEW FURNACE BOTTOMS

A. V. Malakha, L. M. Pokrass, I. I Bekker, and and A. M. Ofengenden

Stalino Metallurgical Plant

In accordance with the existing technology at our Plant, the hearths of medium-capacity open-hearth furnaces were sintered in as follows.

After the furnace was heated until the roof temperature reached 1600-1650°C and the gas checker temperature reached 1100-1150°C, the bottom was covered with ground slag, flushed during the finishing period of carbon-steel heats, of the following chemical composition (in %):

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO
20—23	3—5	3—6	12—14	6—10	37—40	8—10

The slag was thrown by hand in a few portions of 2-3 ton weight and distributed uniformly over the whole furnace. 60-70% of the slag was used for the front wall and the remainder for the banks and the back wall. Each subsequent portion of the slag was thrown only after the preceding one had been melted. The total slag input constituted 9-12 tons. The time taken for slag treatment of the hearth was 9-11 hr.

After the brickwork was thoroughly soaked with slag (a pool of liquid slag appeared on the bottom), the steel tapping hole was opened, the slag was run off from the furnace and the burning-in of the bottom was started. Usually fourteen layers of magnesite powder mixed with slag (the first layer without the slag) and two layers of a mixture of magnesite powder (50%) and roasted dolomite (50%) were burned-in. The total thickness of the burned-in layer was 350 mm.

Ten portions of well-mixed magnesite powder and slag were prepared for each layer. The mixture was made up in such a way that the burned-in layer would contain at least 75% MgO. Five portions of the mixture were thrown onto the bottom and the back wall, and the remaining portions on the front wall and the banks. The average amount of slag per layer amounted to 15% of the total weight of the mixture. The time of burning-in each layer was 7-9 hrs (usually about eight hours).

After the bottom had been burned-in, the slagging was carried out in the same way as before the burning-in. The total time taken for burning-in and slagging was about six days. The temperature of the roof during the burning-in of the layers was maintained at 1550°C (1650°C during some periods), that of the air checkers was maintained at 1200°C, and that of the gas checkers, was maintained at 1100°C. The heat fired was between 11,230,000 to 15,150,000 kcal/hr (13,360,000 kcal/hr on the average).

Burning-in of the bottom by this method took 130-140 hr.

New method of burning-in the furnace bottom. In recent years, especially since the introduction of magnesite-chromite roofs, the heat capacity of the open-hearth furnaces has increased considerably. Therefore, owing to relatively thin burned-in layers (12-25 mm), the slag melted in the course of prolonged heating and soaked through into the lower burned-in layers which were thus enriched with the slag while the upper layers were impoverished and became "dry" so that the magnesite grains would not fuse properly.

It is known that during the burning-in and repairs of the furnace bottom, the formation of each layer is completed while the subsequent layers are burned-in. Therefore, there is no need to attain a complete sintering of each layer while it is heated. It is sufficient if a bond between magnesite grains in the layer is established. This method justifies itself during preventive repairs of the furnace bottom.

In accordance with these considerations, our Plant has developed a new method of burning-in the furnace bottom which involves the application of separate thicker burned-in layers, a reduction in the heating time of each layer, and a reduction in the total thickness of the burned-in bottom.

The decision to reduce the thickness of the bottom was based on the following considerations. The brickwork of the bottom has not a sufficient slope toward the steel tapping hole. Therefore, for the formation of a slope when the burned-in layer near the tapping hole is 250 mm thick it is necessary to increase the thickness of the burned-in layer at the front wall and the banks considerably. This has a negative effect on the furnace operation: the wear of the bottom becomes nonuniform and deep local erosions of the sintered layers occur frequently. By reducing the thickness of the burned-in bottom to 150 mm,

it is possible to reduce the thickness of separate burned-in layers at the front wall and the banks, and to build up the necessary slope for the steel tapping hole.

The main features of the new method of burning-in the furnace bottom are:

1. The burning in of the bottom is carried out with small portions and the scale is added on the front and back walls and on the banks in order to attain a better saturation with the slag and a better fluidity of the slag which accumulates on the bottom.

2. The first thin layer is made only with magnesite powder, grade "Ékstra". This layer constitutes, as it were, a "sponge" for soaking up the slag which runs down the walls and banks, and for bonding the sintered layer with the brickwork of the bottom.

3. The number of sintered layers is reduced from 14-16 to 6 while the thickness of each layer is increased and the total thickness of the sintered bottom is reduced from 250 to 150 mm (at the tapping hole).

4. The total time taken for burning-in a layer, including the time for charging the materials (1 hr), is not more than 3-4 hr on average. The layer is considered to be burned-in if a sample of the layer does not crumble after it is cooled in air.

5. For a rapid fusion of the layers, a high firing rate is maintained during the burning-in process.

This method was first tested in 1957 during the burning-in of a new bottom in one of the furnaces. The number of burned-in layers was reduced to 10 (from 16) while the total thickness of the burned-in bottom was maintained as before (250 mm). The time taken for burning-in each layer, including the charging of materials, constituted 5 hr 18 min. The required thickness of the bottom, its slope, and the contour of the banks were formed during the burning-in of the last four magnesite layers (6th-10th layers).

Subsequently, during the burning-in of the bottom of two more furnaces, the method was improved. The number of burned-in layers was reduced to six, and the duration of burning-in a layer, including charging the materials, constituted: 4 hr 26 min for the second furnace and 3 hr for the third furnace. The total time taken for burning-in the bottom was 40 and 30hr, respectively.

The reduction in the number of burned-in layers was achieved by reducing the thickness of the total sintered bottom by 100 mm and by increasing the thickness of each layer.

At the same time, the thickness of the brickwork of the lower part of the back wall was increased in order to obtain the required contour of the bottom with a reduced amount of magnesite powder, the consumption of which constituted 28-29 tons as compared with 36.8 tons for the first furnace.

Below, we give a description of the technology of burning-in the bottom in the second and the third furnaces.*

At the beginning of the slagging, the temperature of the roof was 1650°C and the temperature of the checkers 1100°C. Ground slag was introduced in small portions. The best results were obtained when portions of 1.3-1.4 ton weight were used. Although the total number of portions of slag added increased, the total duration of the slagging was very short (Table 1). An additional two tons of scale was added on the back wall and two tons on the banks.

The first layer usually consisted of magnesite powder only. The subsequent layers were burned-in from a mixture of magnesite powder and slag (15-20% slag in the mixture). The formation of the contour of the bottom and the banks was started in the second furnace during the burning-in of the second layer, and in the third furnace during the burning-in of the first layer (the slope of the bottom in the first furnace began to be formed when the fifth layer was burned-in). The back wall was smoothed out with a mixture of magnesite powder and dolomite powders (1 : 1) beginning from the third layer, and in the first furnace – beginning from the eighth layer.

Time Table of Burning-in the Bottom of the Third Furnace

December 21, 1958. 14:20-22:40 hr. Slagging. Material used: 10.9 tons of slag (eight portions) and 2 tons of scale.

First layer: 22:40-23:35 hr, 3000 kg of magnesite powder laid on the bottom and the front wall.
December, 21-22, 23:40-1:40 hr. 1000 kg of magnesite powder laid on the back wall.
1.40 hr. The completion of heating the first layer.
Time taken for burning in the first layer: 3 hr.

Second layer: 1:40-3:10 hr. 4000 kg of magnesite powder laid on the bottom and the front wall.
3:20-3:40 hr. 1000 kg of magnesite powder and 250 kg of slag laid on the back wall. Time taken for burning in the second layer: 3 hr.

Third layer: 4:40-6:05 hr. 5000 kg of magnesite powder and 750 kg of slag laid on the bottom and the front wall.
6:15-6:45 hr. 1000 kg of magnesite powder, 9000 kg of dolomite and 400 kg of scale laid on the back wall.
Time taken for burning-in the third layer: 3 hr 50 min.

Fourth layer: 8:30-10:00 hr. 5000 kg of magnesite powder and 1175 kg of slag laid on the bottom and the front wall.
10:05-10:35 hr. 1000 kg of magnesite powder, 900 kg of dolomite and 400 kg of scale laid on the back wall.
Time taken for burning in the fourth layer: 4 hr 30 min.

* The burning-in of the bottoms was carried out under the supervision of senior foremen I. F. Chertkov and V. M. Volkov.

Fifth layer: 11:50-12:30 hr. 2700 kg of magnesite powder and 550 kg of slag laid on the bottom and the back wall; 1000 kg of magnesite powder, 900 kg of dolomite and 1000 kg of scale laid on the front wall.

13:00 hr. The tapping hole closed.
14:00-14:40 hr. 1500 kg of magnesite powder and 1500 kg of dolomite laid on the back wall.
15:00-15:20 hr. 500 kg of scale laid on the back wall.

Time taken for burning in the fifth layer: 3 hr 30 min.

Sixth layer: 15:20-15:40 hr. 2600 kg of magnesite powder laid on the bottom and the front wall, and additional 500 kg of dolomite laid on the front wall.
Time taken for burning in the sixth layer: 1 hr 30 min.

16:50-20:20 hr. Slagging the bottom. 6.0 tons of slag and 5.0 tons of scale used.

20:00 hr. The tapping hole opened and slag run off.

20:20 hr. Charging the furnace for the first heat.

Total time taken for burning in the bottom: 30 hr.

A characteristic feature of the burning-in of the bottom in the second and the third furnaces is an increased consumption of magnesite powder (by a factor of 2-2.5) for each layer and a high consumption of scale for slagging (Table 2). An extensive use of scale assisted in binding the layers to each other and in reducing the time required for slagging the bottom. At the same time, the content of ferrous oxide in the burned-in bottom increased and the content of MgO decreased slightly (Table 3) which did not affect the service life of the bottom, as was shown by subsequent operation. The high rate of firing was also conducive to a faster burning-in of the layers in the second and the third furnace.

TABLE 1

Slagging of the Bottom

Batch number	First furnace		Second furnace			Third furnace		
	slag consumption, kg	time of heating, hr-min	consumption, kg: slag	consumption, kg: scale	time of heating, hr-min	consumption, kg: slag	consumption, kg: scale	time of heating, hr-min
1	4050	5—05	2320	—	1—40	1365	—	1—10
2	3000	3—10	2320	—	1—30	1365	—	0—50
3	2250	1—35	2320	—	1—50	1365	—	0—50
4	2250	1—45	2320	—	2—00	1365	—	0 - 50
5	600	2—00	2320	—	1—50	1365	—	1—00
6	—	—	—	2000	1—15	1365	—	0—30
7	—	—	—	—	—	1365	—	0—45
8	—	—	—	—	—	1365	—	0—45
9	—	—	—	—	—	—	2000	1—40
Total	12150	13—35	11680	2000	10—05	10920	2000	8—20

TABLE 2

Consumption of Magnesite Powder for Burning-in the Open-Hearth Furnace Bottom

Layer No.	Consumption of Magnesite powder kg: first furnace, for the bottom	first furnace, for the front wall	first furnace, for the back wall	second furnace, for the bottom	second furnace, for the front wall	second furnace, for the back wall	third furnace, for the bottom	third furnace, for the front wall	third furnace, for the back wall
1	1280	700	—	2000	1000	—	2000	1000	1000
2	1280	700	—	2700	1300	1400	2700	1300	1000
3	1380	700	—	2700	2900	800*	2700	2300	1000*
4	1380	700	—	2700	2300	800*	2700	2300	1000*
5	1380	700	700	2900	800*	1200*	2700*	1000	1500*
6	1440	700	700	2000	600*	600	1600*	1000	—
7	2700	2000	1000						
8	2700	2000	2000**						
9	2700	700**	2000**						
10	3000	—	1000**						

* Dolomite and scale were added to these layers.
** Mixed with dolomite.

TABLE 3

Data on Burning-in the Bottom of the Third Furnace

Layer.	Consumption of materials for burning in a layer: magnesite powder, kg	magnesite powder, %	slag, kg	slag, %	Time taken for burning in a layer, hr-min	Chemical composition of the burned-in layer, %: SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO
Average	4800	89.0	604	11.0	3—00	6.6	1.6	3.4	8.0	1.05	9.3	69.6
Maximum	6000	80.7	1450	19.3	3—50	8.6	1.85	12.28	13.9	1.42	12.5	77.3
Minimum	2600	100	—	—	1—30	5.7	1.2	0.7	3.25	0.5	8.0	56.7

The operation of the new bottom. A long operation of the new bottoms in the three furnaces burned-in by the new method showed that their durability is higher than that of bottoms burned-in by the old method, and that the idle period for repairs to the bottom decreased significantly in comparison with the average idling periods for the whole shop.

The high durability of the bottoms burned-in by the new method is indicated by the fact that in February, 1959, the bottom of the third furnace had been in continuous operation for 53 heats without an interruption for preventive repairs while the average service period of the bottoms in the open hearth furnace shop is 20-24 heats. Thus the new method, while reducing the time required for the burning-in, ensures a high quality of the burned-in bottom.

* * *

500-TON OPEN HEARTH FURNACE FIRED WITH COKE-OVEN GAS

M. I. Zlochevskii

Stal'proekt

In 1958, the Stal'proekt prepared the design of a 500-ton open-hearth furnace (Figs.1 and 2) fired with coke-oven gas with an addition of fuel oil for one of the iron and steel works. The furnace was intended for making steel by the scrap-ore process with the use of up to 70% liquid pig iron in the charge.

The design envisages an enrichment of air with oxygen which is fed to the flame by a special nozzle. The maximum oxygen consumption is 4000 m^3/hr. It will also be possible to feed the oxygen into the bath.

The coke oven gas of calorific value of 4100 kcal/m^3 and of density of 0.4-0.466 kg/m^3 contains 1.5 to 1.8 g sulfur per m^3. The calorific value (net) of the fuel oil is 9500 kcal/kg and its sulfur content constitutes 2-3%.

During the charging period, when there is the greatest risk of sulfur absorption by the metal, the fuel oil consumption is at its minimum and the consumption of coke-oven gas at its maximum. During the subsequent periods of the heat, when the metal is well covered with slag, the consumption of sulfur-containing fuel oil is increased and the consumption of coke-oven gas is reduced. These changes in the fuel consumption are also dictated by the considerations of the heat transfer from the flame to the bath, i.e., the necessity for ensuring a highly radiant and rigid flame at that time.

The heating regime of a heat in the 500-ton furnace as envisaged by the design is given in the Table.

Out of the total amount of heat supplied to the working space of the furnace by the combined fuel in one heat, 35% of the heat on average is contributed by the fuel oil, and in the course of the heat the fuel oil contribution varies from 10% (during the charging period) to 65% (during the finishing period).

The main process design data of the furnace are: output per year: 450,000 ton; output per hour: 55 ton; output of steel per m^2 of furnace-hearth area: 12.5 ton/m^2 per 24 hour day.

Bath dimensions:

Length of the bottom at the level of the charging doors, m	17.8
Weight of the bottom at the level of the charging doors, m	5.9
Depth of the bath in the middle of the furnace, m	1.2
Area of the bottom at the level of the charging doors, m^2	105

When the total capacity of two 270 ton ladles is utilized the bath should contain at least 540 tons of liquid metal. The bath would then be 62% full.

The bottom of the furnace consists of the following layers: 270 mm thick burned-in magnesite layer, 815 mm thick, magnesite-brick layer, 115 mm thick fire brick course, and 20 mm thick asbestos plate. For systematic temperature measurements of the furnace bottom three thermocouples are installed.

The walls of the working space are laid with magnesite-chromite brick (the upper part of the front wall is laid with chrome-magnesite brick) and are inclined to the horizontal: 50° at the back wall (after sintering) and 70° at the front wall. The thickness of the front wall at the level of the charging doors is approximately 900 mm, and of the back wall – 1400 mm. The front wall extends 400 mm and the back wall 1100 mm outside the base.

The furnace has five trapezoidal charging doors, 18000 or 1600 mm wide, and 1550 mm high. The doors are designed for the use of charging boxes of 2.20 m^3 capacity. For a longer service life of the frames, the side frames of the charging doors are rounded to follow the contour of the columns. The distance between the center lines of the charging doors is 3.15 m, so that it is possible to charge the materials into the furnace with two charging machines at the same time (through the first and the fourth or the second and the fifth charging doors). The

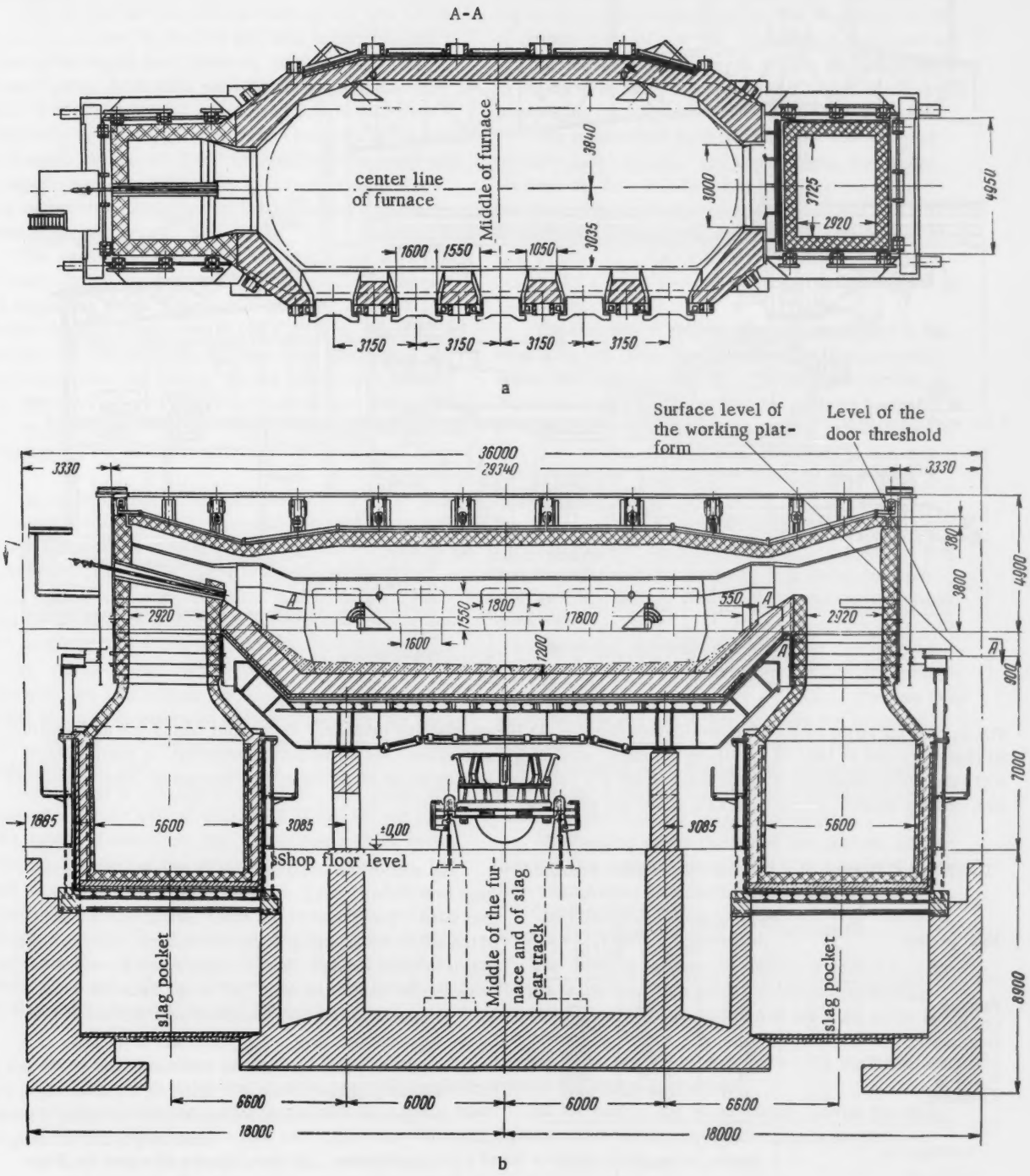

Fig. 1. Plan (a) and front elevation (b) of 500-ton open-hearth furnace.

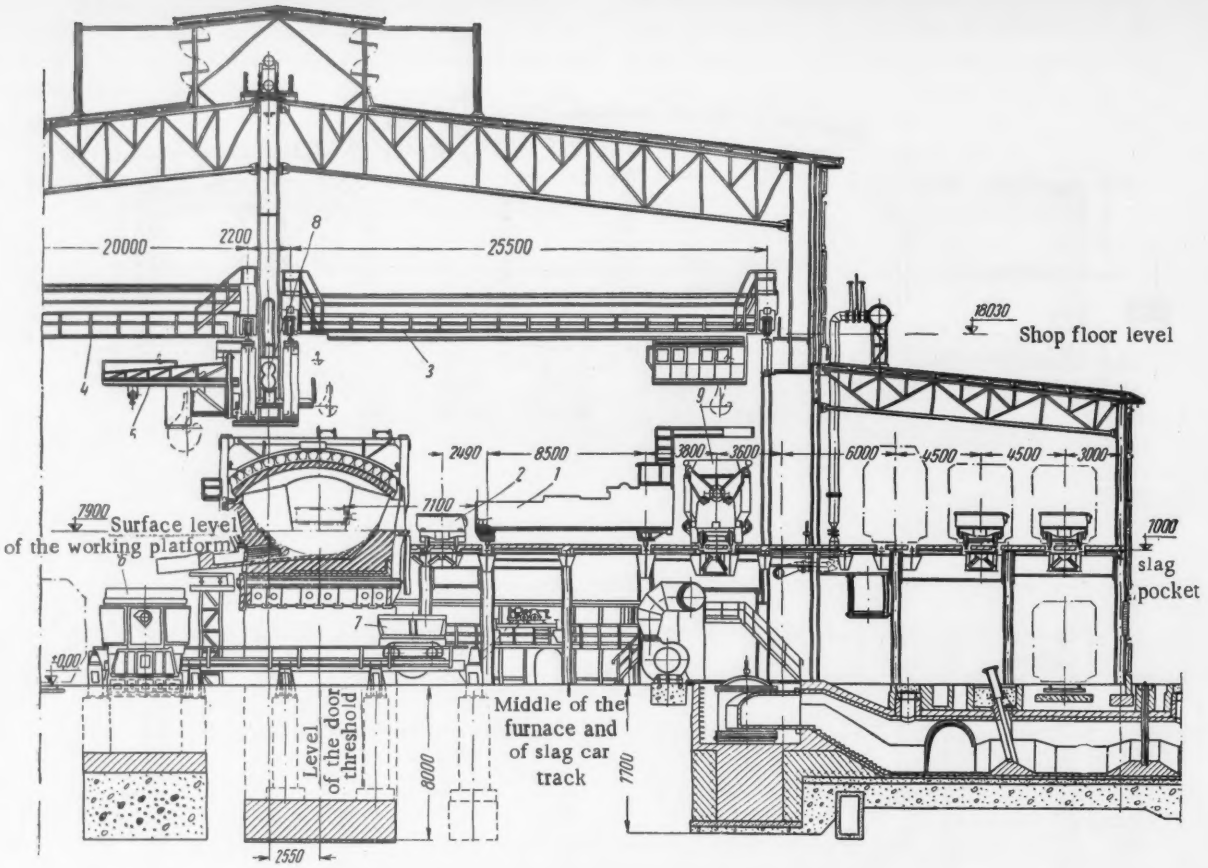

Fig. 2. End elevation of 500-ton open-hearth furnace: 1) 10-ton charging machine; 2) charging box of 2.2 m^3 capacity; 3) charging crane of 180/50 ton lifting capacity; 4) casting crane of 350/75/15 ton lifting capacity; 5) mobile crane fo 10 ton lifting capacity; 6) steel ladle of 270 ton capacity; 7) slag pot of 16 m^3 capacity; 8) separate tanks of evaporation-cooling system; 9) pig iron ladle of 140 ton capacity.

The Thermal Regime of a 500-ton Open-Hearth Furnace

Heat period	Duration, hr	Heat load $\times 10^6$ kcal/hr	Fuel consumption: coke-oven gas, m^3/hr	Fuel consumption: fuel oil kg/hr
Fettling	0.3	28.5	7000	—
Charging	1.5	46.0	10000	500
Heating up	1.5	40.0	8800	500
Liq. metal charg	0.5	34.0	5850	1100
Melting	3.7	34.5	4250	1800
Finishing	2.0	34.0	3000	2400
Average for the heat	—	36.5	5800	1350

distance between the buffers of neighboring charging machines (the bridge of the machine is 9.05 m wide) is then 0.4 m so that there is ample space for maneuvering the machines during the operation.

The roof of the working space is smooth; it is laid from heat resistant magnesite-chromite brick and is 460 mm thick. The height of the main arch above the level of the sill of the charging doors is 3150 mm. Longitudinal beams (angles) for roof suspension are located every 7-8 bricks. The base of the main roof at the back and front walls is supported on water cooled welded beams suspended on the columns.

The brickwork of the working space is supported on a platform consisting of a 20 mm thick steel plate, H-beam and No. 30 channels laid on nine welded supporting girders 980 mm high. The frame of the working space is of rigid construction; its cross bars are also used for fixing the suspension parts of the roof. The facing of the frame is made completely of heavy welded beams.

Cast-iron parts in the furnace structure are used only for the plates for charging door sills and for the plates in the steel tapping hole and the slag notch. The design provides for the possibility of a preliminary assembly of the frame outside the place of erection and subsequent installa-

tion of the frame on the foundations by means of two casting cranes.

The furnace has one-channel ports of the type which is extensively used in the iron and steel industry abroad. These ports require less refractory materials than two-channel ports. With these ports the flame in the working space is better controlled and the slag is collected more efficiently in the slag pockets. The brickwork of the ports is of suspended construction. The weight of the walls rests on supporting plates (three rows of plates) of welded and cast construction, supported on ledges welded to the columns of the port frame.

The vertical section of the port channel is laid with ordinary chrome-magnesite brick. The inside surface of the supporting plates is lined with specially shaped magnesite-chromite bricks, 520 × 120 × 75 mm. For the continuity of the structure, 0.8 mm thick steel plates are inserted between the bricks. For the elimination of turning moments, 1.5 mm steel plates attached on the external side to the angles of the port frame are inserted in the brickwork of the channel walls approximately every sixth row.

In the lower part of the ports the walls of the vertical channel form a smooth aerodynamic transition to the flat part of the roof and the walls of the slag pocket. These parts of the channel are laid with magnesite-chromite brick and are reinforced with steel inserts. Rounded suspension sections are attached to the structural steel members of the furnace by means of shaped heat-resistant cast plates. Corner spaces, formed where rounded sections are adjoining, are laid with rectangular magnesite-chromite (roof) bricks with suspension anchors supporting four bricks each. Temperature expansion is allowed for by gaps filled with corrugated iron.

One burner is installed in each port. The design incorporates burners with an axial feed of fuel oil and a peripheral supply of coke-oven gas. The pressure of the coke-oven gas upstream of the outlet nozzle is 0.2 atmos. The fuel oil is atomized with superheated steam at 15 atm pressure and 350°C. The mixing and equalization of the speeds of steam-oil emulsion and gas takes place in the burner nozzle. The discharge velocity of the mixture is about 40 m/sec. The inclination angle of the burner can be changed by means of an electric drive.

It is proposed to test two types of burner mounting: in one the burner is mounted in a water-cooled jacket, and in the other no provision is made for cooling but the burner is protected with a special frame provided with an evaporation cooling system.

The roofs of the slag pockets are flat, of suspended construction, so that it is possible to have wide (5 or 6 m) slag pockets of large capacity. The volume of the two slag pockets is approximately 360 m^3 and their capacity is sufficient for about 350 heats, i.e., approximately five months of continuous furnace operation.

The whole suspension part of the roof of the slag pocket between the vertical channel and the partition wall of the regenerators is made from magnesite-chromite bricks reinforced with steel interlays. The inside lining of the slag pocket walls as well as the bottom is made of chrome-magnesite bricks. Under these conditions one can obtain slag which is easy to dispose of mechanically by means of scraping machines and a system of conveyors transporting the slag to the dump car or the slag pot.

The regenerators have one chamber and one-pass checkers 7.225 m high. The upper fifteen rows of the checkers are laid with forsterite bricks by the Cowper method. The lower rows of the checkers are laid with fire bricks by the Siemens method. The volume of one checker is 379 m^3, i.e., 3.61 m^3 per m^2 of floor area. The height of the space above the checkers is 1.55 m, and below the checkers 1.8 m.

The chamber of the checkers is covered with a flat suspension roof, laid from heat resistant high-alumina bricks, 420 × 230 × 100 mm. The roof is suspended on transverse beams of the regenerator structure by means of compound suspension members. The roof bricks have tongs and grooves on their contact surface so that it is possible to have a fairly good gas-tight brickwork. A special sealing layer is laid on the outside surface of the roof to provide for a better tightness.

The frame of the regenerators and slag pockets is of a rigid all-welded construction; it is assembled from separate large units so that it can be erected in a short time.

The design provides for washing the checkers with high-pressure (up to 10 atmos) water as well as for blowing with steam or water-steam emulsion. The dust from under the checkers can either be blown out by means of steam nozzles mounted in the bottom of the regenerators (without shutting down the furnace), or removed with scrapers into a channel under the slag pockets when the furnace is shut down for hot or cold repairs.

All changing valves (inlet and flue gas) are accommodated in a common pit covered with a removable plate. This arrangement considerably facilitates repairs.

The furnace is amply instrumented. The control of the thermal regime is automated.

The liquid steel from the furnace is poured into two 270 ton ladles through a spout divided symmetrically into two halves. The distribution of the steel to the ladles is regulated by means of an attachment operated by two electric hoists located on the platform for the hoists which operate the charge door covers.

All the units of the valve change system, the charging door cover lifting, and spout stoppers are provided with a central lubrication system.

The slag from the furnace is discharged into three slag pots of 16 m^3 capacity. One pot is placed on a car under the middle charging door and when it is full it is transferred into the casting bay by means of an electric drive, while the remaining pots are located in the casting bay. The slag from the furnace flows under gravity into these two pots through inclined troughs from two slag holes in

the back wall. For a longer service life, the slag holes are provided with coolers lined inside with magnesite bricks. If the slag yield in a heat is 90 tons (18% weight of the charge) and the average specific weight of the liquid slag is 2.25 tons/m^3, then the capacity of three slag pots is adequate for 1.2 heats. The furnace is provided with an evaporation cooling system which generates steam at 3-4 atmos pressure. A waste heat boiler of KU-100 type, designed to supply steam at 18 to 45 atmos pressure and 400°C, is incorporated in the furnace design.

The necessary draft is provided by the flue-gas fan of the waste heat boiler. An extra source of draft is provided by the stack 85 m high and 3.0 m in diameter. The waste gases are cleaned before they are discharged into the atmosphere.

The cost of the erection of this furnace is 900,000 rubles lower than the cost of a furnace of the same capacity fired with a mixed gas (estimated for a comparable rate of throughput). The consumption of concrete and reinforced concrete is reduced by 45%, refractories by 30%, red brick by 30%, steel (section steel, castings and forgings) by 15%. Capital cost per ton per year is reduced by 18%.

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ROLLING SQUARE SECTIONS WITH SHARP EDGES

Cand. Techn. Sci. N. V. Litovchenko, and Roll Designers
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The roll designs for rolling square sections with sharp and with round edges have several common features. However, they differ in the shape of the grooves in the last four passes and in the magnitude of the reductions.

For rolling square sections with rounded edges it is important to obtain, in the last three passes, a regular intermediate square and then a diamond with edges rounded to such an extent as to fill the required round edges in the finishing square pass. For square sections of side A= 50-90 mm, this condition is satisfied if the ratio of the diagonals of the intermediate diamond, h/b = 0.62-0.72 and the radius of the curvature of the diamond apex, R = (0.2-0.30)A.

The shape and the dimensions of the intermediate diamond are shown in Fig. 1a.

The rolling of a square section with sharp edges has its specific features and can be successfully carried out only if the grooves of the last four passes are designed on the basis of a diamond-square pass arrangement with sharp edges in the grooves (Fig. 2). In addition, the intermediate diamond should have a special shape of the apex so that a sharp edge can be obtained in the finishing pass (Fig. 1b).

For obtaining sharp edges in the final pass, the shape of initial square billet entering the first diamond pass is of great importance. The edges of the initial square section should have as small a curvature as possible.

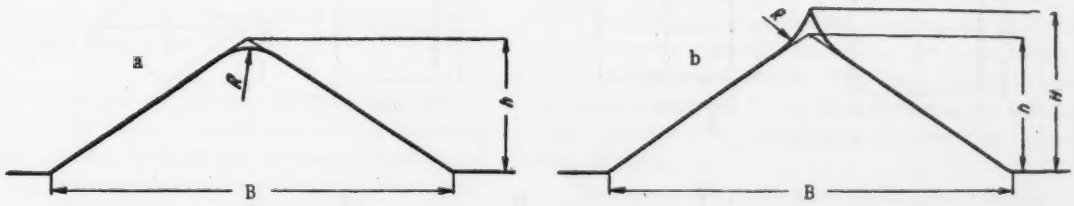
The scheme of reductions during the rolling are of decisive importance. While for rolling a section with rounded edges the mean drafts are usually μ = 1.3-1.35 from the intermediate square to the final square, the rolling of a square section with sharp edges can be carried out by two schemes depending on the regime of the reductions.

In the first scheme, high drafts are used in intermediate diamond and final square passes. The intermediate diamond has a special contour of the apex; high drafts are proposed in the last four passes of the diamond-and-square on edge with sharp edges system. In the second scheme, small drafts in the last four passes are recommended; it is assumed that, with small reductions and at the same time a small distance between the rolls, sharper edges will be obtained. Small reductions do not produce "springing" of the stand and hence the section with sharp edges, especially in the gap between the rolls, can be produced more accurately.

Both schemes and reduction regimes were tested during the rolling of a square section of side A = 90 mm rolled on a medium-section mill consisting of nine working stands of cross-country type. The section was passed once on each stand.

The first scheme of rolling the section from 175 × 150 mm billet is shown in Fig. 3 and Table 1.

The reductions in the first version of this scheme were then modified by decreasing the draft in the inter-



Stand No.	Section	h	B	R
VIII	⌀ 50	27	88	9
"	" 60	34.5	106	12
"	" 65	39	118	12
"	" 85	53.5	137	36

Stand No.	Section	h	H	B	R
VIII	⌀50	30	31	90	43
"	" 60	35.5	37.5	104	60
"	" 65	37	40.5	112	159

Fig. 1. Intermediate diamond section for rolling into a square section: a) with rounded edges; b) with sharp edges.

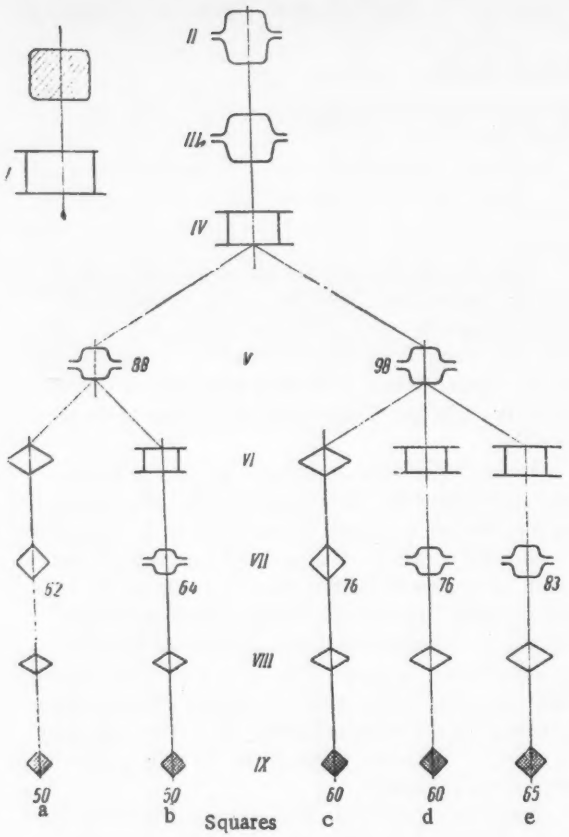


Fig. 2. Arrangement of passes for rolling square section with sharp edges (a, b), and rounded edges (c, d, e): stands I to IX.

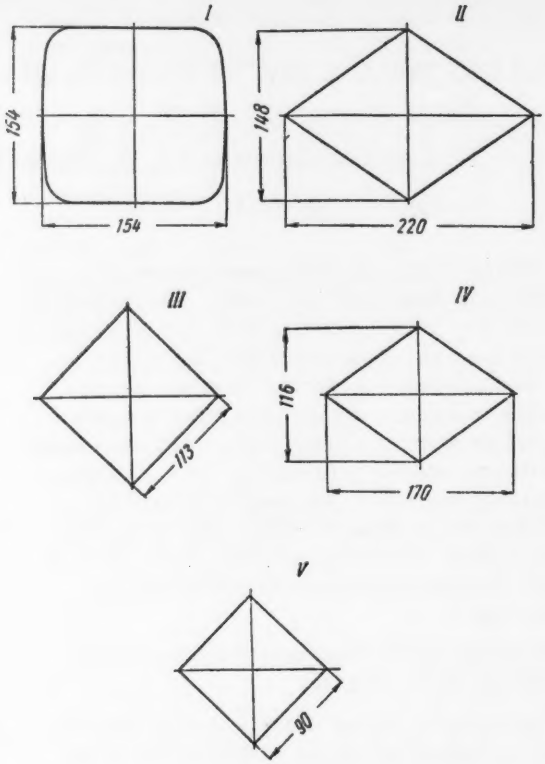


Fig. 3. Arrangement for rolling 90 square with sharp edges in five passes: I-V) stands.

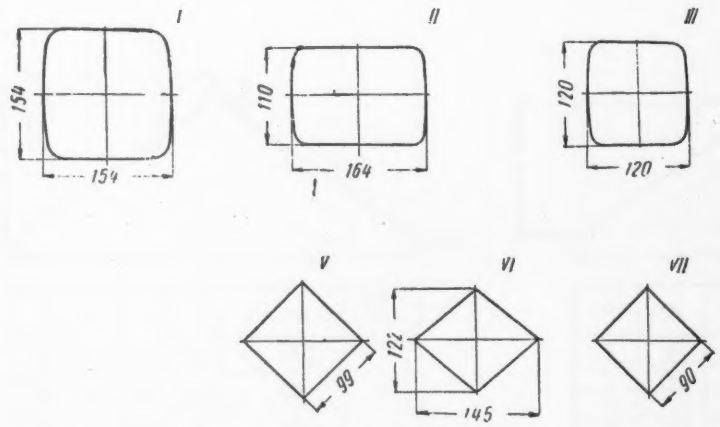


Fig. 4. Arrangement of passes for rolling 90 mm square with sharp edges in seven passes: I-V) stands.

TABLE 1

Rolling 90 mm Square by the First Method

Stand No.	"Dimensions of the rolled piece, mm"		Cross-section area, F	Side or diag. reduction, Δh	Draft, μ	Remarks
	height, h	width, b				
I	155	155	24000	20	1.09	Turned through 45°
II	150	220	16500	50	1.45	Turned through 90°
III*	116.5	116.5	13600	55	1.21	Turned through 90°
IV	116	170	9850	48.5	1.38	Turned through 90°
VII	90	90	8100	43	1.22	Turned through 90°

* Type of the pass: square on edge

TABLE 2

Rolling 90 mm Square by the Second Method

Stand No.	Height, h	width, b	Cross-section area, F	Side or diagonal reduction,	Spread, mm, Δb	Draft, μ	Type of the pass	Remarks
I	154	154	23700	26	9	1.1	Box type, square	
II	148	220	16300	56	17	1.48	Diamond	Turned through 45°
III	113	113	12800	60	12	1.27	Square on edge	Turned through 90°
IV	116	170	9850	44	10	1.3	Diamond	Turned through 90°
VII	90	90	8100	42	12	1.22	Square on edge	Turned through 90°

mediate diamond pass. The service life of the rolls was thus increased. The reduction regime in the second version of the first scheme for 180 × 145 mm billet is shown in Table 2.

Both regimes of reduction are designed for rolling the billet in five stands in accordance with the following procedure: the hot billet is rolled in the first four stands; the section is then transferred by pull-over transfer to the second train of the rolling stands and is entered into the seventh stand, which is the finishing stand in this rolling scheme; the remaining stands are not used. This scheme of rolling square sections from 180 × 145 and 175 × 150 mm billets is quite acceptable and provides for a satisfactory shape of the sharp edges.

TABLE 3

Reduction Regimes for Rolling Sections from 180 145 mm Billet

Stand No.	Dimension of the section		Cross section area, mm², F	Side or diagonal reduction, mm, Δh	Spread, mm,	Draft,	Remarks
	height, h	width, b					
I	154	154	23700	26	9	1.1	
II	110	164	17700	44	10	1.25	Turned through 90°
III	120	120	14100	44	10	1.25	Turned through 45°
IV	132	180	11900	27	21	1.18	Turned through 90°
VII*	140	140	9800	40	8	1.22	Turned through 90°
VIII	122	145	8850	18	5	1.11	Turned through 90°
IX	90	90	8100	17	6	1.09	

* Pass type: square on edge

In the course of the mastering of the rolling of square sections with sharp edges a suggestion was put forward that the sections should be rolled not in five but in seven stands. At the same time, the reduction in the last stands should be made very small (Fig. 4, Table 3).

Rolling by the second scheme gave unsatisfactory results: small drafts, and hence small reductions in the last two passes (prefinishing and finishing), did not ensure the formation of a satisfactory sharp edge. In addition, because of a small difference between the two diagonals of the prefinishing diamond (122 × 145 mm) the entry of the piece into the finishing stand was made difficult.

Therefore, small reductions are not recommended if one wants to obtain well-formed edges of the square. Sharp edges on square section can be obtained if high reductions in the last passes and a diamond pass of a special shape are used. Therefore, the first scheme of rolling is preferable.

The rolling of square sections with sharp edges necessitated the installation of an additional mechanism. When the final section leaves the finishing pass in which the grooves are V-shaped, the section gets twisted around its axis under its own weight. The longer the piece rolled, the more extensive is the twisting of its rear end and the more extensive is the distortion of the corners on the vertical diagonal.

To prevent the piece from twisting, free-running rollers are installed behind the finishing stand in the line of rolling. In this way the rolled piece is kept between two supporting elements: the pass and the roller; the piece is delivered in a steady position relative to its longitudinal axis and the sharp edges are not distorted.

ROLL DESIGN FOR ROLLING RECTANGULAR SECTIONS

I. M. Konovalov, Roll Designer, and I. F. Revenko,
Head of the Section Mill

Stalino Metallurgical Plant

In the design of a new pass arrangement for rolling narrow sections, it was aimed, as usual, to find those arrangements which would give a minimum spread and a minimum number of passes for the same displaced volume of steel.

For instance, by rolling an oval section in a square pass (Fig. 1a) we obtain a displaced area equal to 222 mm^2 and a spread area equal to 37.6 mm^2. 17% of the displaced cross-sectional area is the spread area. On rolling a diamond section in a square pass (Fig. 1b), we obtain a displaced area of 60.8 mm^2 and a spread area of 7.2 mm^2; the spread constitutes 11.8% of the displaced area. When a square section is rolled in plain rolls (Fig. 1c) the displaced area constitutes 100 mm and the spread constitutes 60 mm^2 (i.e., 60%). By rolling a diamond section in a diamond pass(Figs. 1d and 2) we obtain a displaced area of 663.8 mm^2, and a spread area of 120 mm^2; the spread constitutes 18% of the displaced metal.

It is seen from the examples quoted above that in plain rolls the percentage of displaced metal contributing to the elongation is the smallest and that contributing to the spread is the highest. The metal which forms the spread undergoes a second deformation in the subsequent passes.

With the object of reducing the number of passes for rolling sections of 1 : 2 width-to-thickness ratio without impairing the quality of the rolled piece, the diamond-diamond pass arrangement was used (Fig. 2), but the square section with convex sides was passed between plain rolls instead in the edging pass. This pass arrangement was found to be better because it made the roll adjustment easier, provided for large drafts and reduced the portion of metal in the spread.

The diamond-diamond pass arrangement was used for rolling 8 × 16, 21 × 26, 20 × 30, 20 × 35, 18 × 35 mm and some other sections. The tests on rolling 16 ×

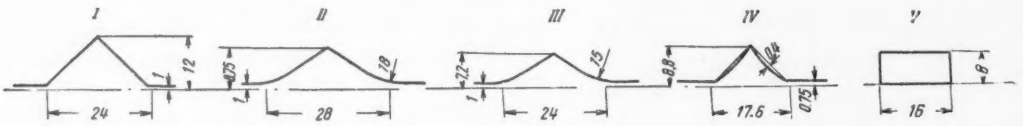


Fig. 1. Pass arrangement: I, IV) squares; II, III) diamonds; V) plain roll.

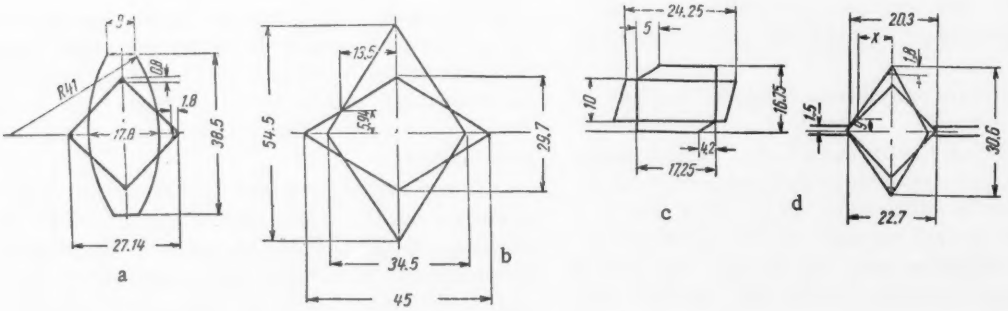


Fig. 2. Finishing passes of the diamond-diamond system for rolling an 8 × 16 mm section: a) oval section in square pass; b) diamond in square pass; c) square section in plain rolls; d) diamond section in diamond pass.

× 35 mm section with the use of a prefinishing square with convex sides gave unsatisfactory results: because of a high reduction in the finishing pass, the variation in the width of the section exceeded the tolerances specified by GOST.

For rolling 8 × 16 mm section, the five passes of the finishing line (Fig. 2) were designed for this section only, and the remaining passes – roughing and reducing – were common for all sections rolled on this mill. Diamond passes No. 2 and 3 have grooves with rounded edges. The radius of curvature R is determined on the basis that the tangential point B (Fig. 3) is at a distance equal to 2/3 of the line AD (side of the diamond) from D:

$$R = \frac{1}{\operatorname{tg}\frac{\beta}{2}}\left(\frac{a}{3} - \frac{S}{2\sin\beta}\right),$$

where S is the gap between the rolls; a is the side of the diamond ($a = \sqrt{h^2 + b^2}$).

With this construction of the diamond, the adjustment of the rolls and rolling equipment is simplified and the formation of laps is prevented. The passes are arranged without down or up pressure.

The arrangement of passes for rolling 21 × 36, 30 × × 16, 30 × 18, 30 × 20, 35 × 18, and 35 × 20 mm sections is shown in Fig. 4. Three diamond passes (I, II, and III) are common for all sections. The size of the diamond

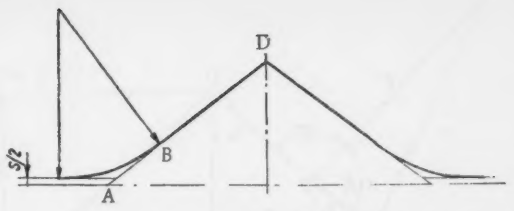


Fig. 3. Diagram of the diamond pass for calculating the radius of the curvature.

passes can be adjusted by changing the distance between the rolls. The grooves of the diamond passes have slightly rounded edges so that high drafts can be used; the small apex angle of the diamond facilitates the entry of the section into the pass. An additional space determined by the magnitude l (Fig. 5) is available for the spread of the metal. The radius of curvature can be determined by the formula which is based on the condition that the tangential point B is at the distance equal to 1/3 of the diamond side from the point A:

$$R = \frac{a\cos\beta}{6\cos\beta\cos(\alpha + \beta_1)},$$

where a is the side of the square: $a = \frac{1}{2}\sqrt{h^2 + b^2}$;

β is the angle determined from the formula $\operatorname{tg}\beta_1 = \operatorname{tg}\beta - \frac{3S}{2a\cos\beta}$; R is the curvature radius of the chamfer at the top of the groove.

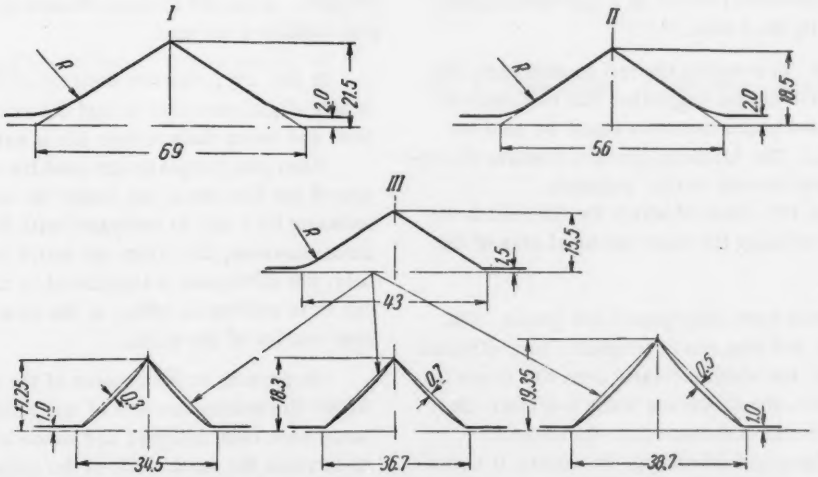


Fig. 4. Arrangement of passes for rolling sections by the diamond-diamond scheme.

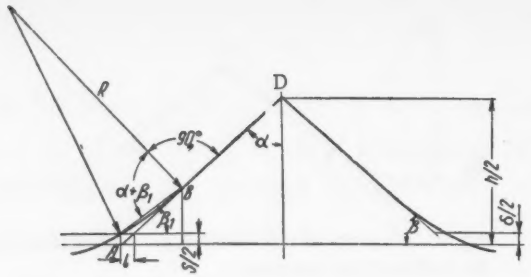


Fig. 5. The design of the diamond pass.

Thus, of all the pass arrangements described above, the most uneconomic method of rolling sections from squares and rectangular sections is in plain rolls. An efficient arrangement of passes is the diamond-diamond system which has a smaller number of passes.

The arrangements of passes described for rolling steel section are being used at the mills of the Stalino Metallurgical Plant and they have resulted in a reduction in the number of passes by two (compared with the previous arrangements, with the use of an edge pass) and an improvement in the quality of the section rolled.

* * *

REDUCING THE CONSUMPTION OF ROLLS AT THE BILLET MILL

B. M. Ilyukovich

Senior roll designer of the Chusov Metallurgical Factory

Billet mill 800 at our Plant consists of two three-high stands arranged in one line and equipped with lifting and tilting tables. In both stands, the sections are rolled in twin-groove box passes (6-20% slope of the side walls) and are turned after every two passes.

The rolls of the first stand are made from cast steel 50-55 and the second from semihard cast iron. High reductions employed at the mill and an unsatisfactory design of the manipulators resulted in a high consumption of rolls, especially steel ones.

With a view to reducing the roll consumption, the Plant decided to adopt the suggestion that templates of minus, nominal and plus dimensions should be used for dressing the rolls. The following specific features of rolling are taken into account in this proposal:

a) there are two stands of which the first one is intended only for reducing the cross-sectional area of the section rolled;

b) both stands have twin-groove box passes. The minus, nominal, and plus sets of templates have different widths of passes; the width increases from the minus to the plus templates, the difference being 6-8 mm; the normal templates are of intermediate dimensions.

Since, in the course of rolling, the section is turned after each upper pass and is entered between the middle and the lower pass so that the height of the section becomes its width, the introduction of templates of various widths involved various heights of the templates for the upper passes, the height increasing corresponding to the width from the minus to plus sizes.

The new rolls are always made according to the minus templates. After the rolls have served for one campaign they are dressed according to nominal templates of a larger width. The passes are thus renewed but the working diameters of the rolls remain almost unchanged. When the rolls are dressed the second time, the plus templates are used.

In this way, after two dressings of the roll, the diameter is only slightly reduced so that the rolls are, in effect, as new, and hence their service life is extended.

When plus templates are used, the width of the last pass of the first stand, and hence the width of the section, increases by 6 mm as compared with the original width. Since, however, the billets are rolled in the second stand only, this difference is eliminated in the second pass of this stand and has no effect on the final dimensions of the cross section of the billet.

At present, at the expense of the tolerances in the billet dimensions, two sets of templates for the second stand have been designed and hence it has been possible to increase the service life of the rolls by one dressing, i.e., by 16-20%. The number of sets of templates of different dimensions can be increased depending on the operating conditions at the mill.

THE INSTALLATION OF TUBE GUIDES BETWEEN THE STANDS OF MILL 250

V. P. Emel'yanov

Magnitogorsk Metallurgical Combine

Until now, between the prefinishing stands of the second and the third middle group at the continuous wire mill 250, there have been special troughs for guiding the section into the passes. The troughs consisted of four removable shaped parts made of cast steel (Fig. 1). During normal operation, the troughs were quite satisfactory in service but when the speed of rolling was increased, hot section would frequently leave the trough and not enter the pass. Such sections had to be rejected and considerable time was lost on the manufacture of a new trough and the replacement of the old one.

P. F. Volkov suggested a simple new design of an entry guide in the form of a funnel (Fig. 2) with an extended entry such that it would be impossible for the section to be ejected out of the guide. The section is now entered accurately into the pass. The tube guide can be made by casting or can be machined on a lathe from a steel piece. The base and the tubing for cooling the pass are electrowelded to the guide tube. A rubber hose for supplying cooling water to the pass is attached to the free end of the tube.

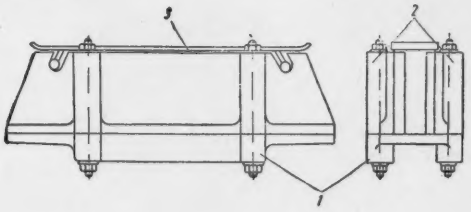


Fig. 1. Trough guide: 1) base; 2) side walls); 3) top.

It is seen from Fig. 2 that the tube guide is simpler in design than the trough guide. There is no difficulty in replacing a worn tube guide by a new one since it can easily be taken out from the groove in the entry table. Shoulders, which constitute an integral part of the base or are welded to it, prevent the tube guide from twisting or overturning.

As a result of the adoption of the tube guide, the rejection of materials due to the section being thrown out of the guide has been completely eliminated and the idling periods have been reduced so that some substantial savings have been achieved. The tube guides can be used on all stands of similar design.

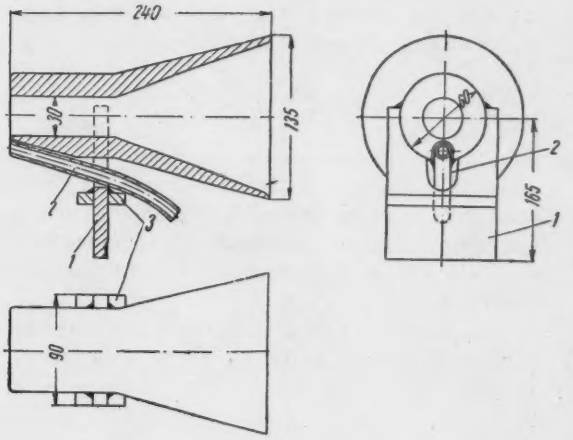


Fig. 2. Tube guide: 1) tail piece; 2) tube; 3) shoulder;

* * *

ALIGNING THE TRANSFER CHAINS OF COOLERS

A. F. Krisanov

Equipment Assistant Manager in No. 2 Shop at the Nikopol' Tube Plant

The transfer chains of rolling mill coolers become non-uniformly elongated as the pins and the slots in the plates become worn. As a result, the cleats of parallel chains get out of line and therefore a section or a tube which is transported can be skewed. To prevent the distortion of the tubes, the worn chains have to be replaced.

With the 20 m length of the cooler section (at one of the mills), the lag between the cleats of the most elongated chains and the least elongated ones reached 200 mm and the cooler became unsuitable for operation.

To bring the fingers of the chains into one line we applied the method of partial replacement of the links of the elongated chains. The chains of the cooler section (Figure) are arranged in such a way that the cleats of all the chains are brought into one line and the elongated chains are shortened to the length of the least extended chain. The number of links which have to be replaced in each chain is determined from the equation:

$$n_n = \frac{L_1 - L}{t_1 - t_n},$$

where L is the distance between the extreme cleats of the least worn chain; L_1 is the distance between the extreme cleats of the extended chain which has to be shortened; n_n number of links to be replaced; t_1 pitch of the links of the chain to be shortened; t_n pitch of the links of the retained chain.

The number of links n_n to be replaced refers to the length of the chain in section L_1. For the whole chain, including the idle branch, the number of links which have to be replaced will be

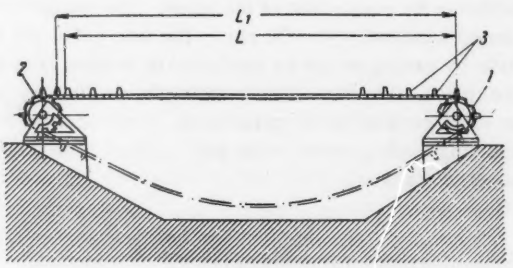
$$N = n_n \frac{l}{L_1},$$

where l is the total length of the chain.

The new links must be distributed uniformly between the old links over the whole length of the shortened chain.

The maximum allowable elongation of the pitch of a chain, when old and new links are used, depends on the strength of the worn links. The chain must be replaced completely when the openings in old plates become so worn that the chain may break.

The use of this method of chain alignment at the tube rolling mill made it possible to reduce the consumption of chains by half.



Pull chains of the cooler: 1) driving wheel; 2) free running wheel; 3) cleats.

* * *

ECONOMIC ADVANTAGES OF ROLLING THIN-WALL TUBES ON AUTOMATIC MILLS

Cand. Tech. Sci. V. Ya. Ostrenko, and Engineers L. D. Bobrakov, A. M. Tkachenko, and E. I. Ulinskaya

Ukrainian Tube Research Institute

In recent years at the automatic tube-rolling mills of the Nikopol' Yuzhnotrubnoi and Zakavkaz Metallurgical Plants, the production of tubes from carbon steel with a minimum wall thickness conforming to GOST 8732-58 has been mastered. The thickness of the walls of the tubes of 168-219 mm diameter corresponds approximately to the International Standards Specifications (Table 1).

Some consumers ask for oil pipes, steam pipes, drilling pipes and other types of pipes with thinner walls than supplied hitherto.

The production, however, of tubes with thin walls involves certain difficulties owing to the reduced output of the tube rolling mills, a lower percentage of acceptable product and a higher power consumption.

TABLE 1

Hot-Rolled Tubes of Minimum Wall Thickness

Standard specifications or Plant.	Tube diameter, mm			
	168	219	273	325
	minimum wall thickness, mm			
GOST 8732-58	5.0	6.0	7.0	8.0
DIN-2448	4.5	6.0	6.5	7.5
International	4.5	5.9	6.3	7.15
Nikopol' Yuzhnotrubnoi Plant	5.0	6.0	7.0	8.0
Zakavkaz Metallurgical Plant	5.0	6.0	7.0	8.0

The object of this work was to determine technical and economic factors and to establish a range of sizes for tubes of 168-325 mm in diameter from carbon steel which would be economically justifiable to manufacture.

The investigation was carried out at the automatic mills of the Yuzhnotrubnoi and the Zakavkaz Metallurgical Plants.

In addition to rolling tubes of 168-325 mm of tube wall thickness within the limits specified by GOST-8732-58, attempts were made to roll tubes with thinner walls. In particular, 25 tons of 273 × 6.5 mm tubes were rolled.

During the tests, the schedule for rolling tubes was arranged in such a way that the length of the finished tubes of all sizes was approximately 12 m. Therefore, the lengths of the initial billet and hence the weight of the tube of thinner wall had to be correspondingly smaller.

With the reduction in the wall thickness of the tube by 1 mm the total power consumption for all the mills increased by 4-17%.

At the Zakavkaz Metallurgical Plant the hourly output (in tons) of the tube rolling mill with an automatic stand for all sizes of tubes fell by 10.2-22%, in terms of the weight (tons) of tubes rolled, but in terms of length (meters) the output of 168 mm tubes remained practically the same; for 219-273 tubes the output increased by 1-1.5%; for 325 mm tubes it fell by 3% (owing to variations in the lengths of tubes rolled). The hourly output (in tons) of the automatic mills at the Yuzhnotrubnoi Plant for all tube sizes fell by 1.7-16.4%, but the content in meters increased from 2.1 to 10.3%.

The production of thin-walled tubes at the Zakavkaz Metallurgical Plant and the Yuzhnotrubnoi Plant involved an excessive consumption of steel.

These losses were compensated to a large extent by the total saving in steel owing to the reduced wall thickness.

On comparing the quality of the tubes from the two Plants one can conclude that the output of first-grade tubes is slightly higher at the Zakavkaz Metallurgical Plant than at the Yuzhnotrubnoi Plant. This is explained by a better design of the mill, a higher rigidity of the stands and higher speeds of rolling on the piercing and automatic mills of the Zakavkaz Metallurgical Plant.

The higher consumption of steel at the Zakavkaz Plant was entirely due to irregularities in the operation of the automatic mill. The main causes are some design defects, the slow operation of the mechanism for mandrel changing, a longer time required for the auxiliary operation owing to the necessity for removing the mandrel-support bar in order to change the mandrel, and the frequent loosening of the upper roll owing to difficulties in adjusting cotter mechanism and the drive correctly.

TABLE 2

Cast of Tube Billets Per Ton and Per Meter of Tubes

Tube size mm	Cost of billet, rubles-kopeck			
	Yuzhnotrubnoi Plant		Zakavkaz Plant	
	per ton	per ton	per ton	per ton
168×5	856—83	17—20	—	—
168×6	836—56	20—06	924—97	22—18
168×7	—	—	902—35	25—06
168×8	819—28	25—84	898—11	28—33
219×6	829—80	26—18	934—73	29—55
219×7	829—80	30—39	908—44	33—30
219×8	819—28	34—13	896—42	37—37
273×6.5	851—46	36—26	—	—
273×7	—	—	934—15	43—71
273×8	826—34	43—25	909—03	47—59
273×9	819—28	47—63	914—56	52—70
325×8	834—42	52—15	920—18	56—88
325×9	820—84	57—80	910—68	64—13
325×10	—	—	905—80	70—22

TABLE 3

Cost of Tubes

Tube size, mm	Cost, rubles-kopeck			
	Yuzhnotrubnoi Plant		Zakavkaz Plant	
	ton	m	ton	m
168×5	1238—52	24—87	—	—
168×6	1206—79	28—94	1343—64	39—22
168×7	—	—	1272—79	35—35
168×8	1138—98	35—98	1227—06	38—68
219×6	1111—40	35—06	1263—68	39—90
219×7	1073—16	39—31	1190—99	43—65
219×8	1044—00	43—50	1147—22	47—82
273×6,5	1123—73	47—88	—	—
273×7	—	—	1267—23	58—85
273×8	1059—28	55—46	1198—20	62—73
273×9	1033—72	60—10	1174—97	67—84
325×8	1080—48	67—53	1171—54	72—59
325×9	1039—87	73—23	1128—08	79—44
325×10	—	—	1103—30	85—76

In order to determine the economics of rolling thin-walled tubes on automatic mills, the cost of tubes of minimum wall thickness made at these Plants was compared with the cost of tubes with a thicker wall. As is

known the cost of tube is comprised of the cost of the billet, the production cost and the overhead costs of the Plant. The cost of tubes was compared under these headings.

In accordance with the results of the rolling process the consumption coefficients for the billets for each size of tube under study was determined. Then, the consumption of tube billets per one ton of tubes was converted to a value expressed in the terms of money by multiplying the steel consumption coefficient by the planned price per ton of billets. Knowing how many meters of tubes of each size comprise one ton one could determine the cost of billet per one meter of finished tube.

It is seen from Table 2, that the cost of billet per ton of tube increases as the thickness of the tube wall decreases but the cost per one meter of tube decreases as the tube wall thickness decreases.

Indirect expenditure on production and overhead expenses in the Plant were determined for each tube size in accordance with the "difficulty coefficients."

It is seen from Table 3 that the cost at the Plants of 1 ton of tube, as well as the cost of billet which constitutes 70-80% of the total cost at the Plant, increases as the wall thickness decreases, but it decreases per meter of tube as the wall thickness decreases. The results quoted confirm that it is economically advantageous to make thin-walled tubes on automatic tube mills.

For a better quality and a higher yield of acceptable product it is recommended:

a) to equip the plant concerned with special lathes for machining mandrels;

b) to improve the mechanism for changing the mandrel, to improve the mounting of working rolls and the arrangement of the cotter mechanism of the automatic mill at the Zakavkaz Plant.

For a more accurate accounting of the tube rolling mills and in order to provide an incentive to the workers, it is expedient to introduce a bonus scheme for the workers engaged in the production of thin-walled tubes.

* * *

New Techniques

AN ACTIVE INNOVATOR

N. G. Chernokhlebov

Taganrog Metallurgical Plant

A cheap but highly effective method of insulating gliding tubes has been developed at the Taganrog Metallurgical Plant. Spikes, 65 mm long, are welded to the tube surface at a distance of 100 mm from each other. 5-6 mm thick asbestos plates are fixed on these spikes and then 10-15 mm thick steel plates are laid on top of asbestos plates and tightly fastened with screws. When the plates are heated, the heat is conducted from them through the spikes to the tubes in which cold water circulates. As a result of the introduction of the new method of insulation the service life of gliding tubes increased considerably and resulted in a saving of 195,000 rubles annually.

This method was developed by an active innovator, the head of the thick-plate section of the rolling mill at our Plant, I. E. Shabalin.

During his twenty-nine years of employment at the Plant, I. E. Shabalin has made many a suggestion for technical improvements. Here are just a few of them.

The grooved coupling mounted on the ends of the lower driving shaft used to wear very rapidly. The idling time of the mill for this reason constituted 116 hours annually.

I. E. Shabalin suggested an increase in the length of the grooves from 300 to 450 mm; in this way, the pressure per unit area of the coupling was almost halved and its service life increased.

At one of the stands of the rolling mill the right hand necks of the upper and the lower rolls often broke. This caused stoppages and a high consumption of expensive rolls.

Ivan Eliseevich Shabalin, an innovator at the Taganrog Metallurgical Plant.

On the suggestion of L. E. Shabalin the diameter of each neck (520 mm) was increased by 40 mm and thus it was possible not only to increase the service life but also to increase the draft, reduce the number of passes and increase the output of the mill.

For a long time, the middle roll of the mill had suspension guides fixed to the block with bolts. In the course of the rolling process the rolled piece frequently dislocated the guides together with the block; the lugs of the guides broke, the support bars broke too and the middle roll became enveloped with steel.

On the suggestion of I. E. Shabalin, a new type of guide which is attached to the block by a bolt and a spring has been developed. With this guide the rolled section can pass smoothly from the rear end of the mill to the front lifting table. Instead of 115 suspension guides only 36 guides are used up in a year. Annual savings constitute over 100,000 rubles.

More than seventy suggestions for improvements, which were adopted and resulted in substantial savings, stand to the credit of I. E. Shabalin.

The work of L. E. Shabalin was highly praised by the Soviet Government. He was awarded the Order of Lenin, the Order of the Red Banner of Labor as well as some medals of the Soviet Union.

* * *

Organization of Production in Factories

UTILIZING POTENTIAL SOURCES OF OUTPUT INCREASE

V. A. Rassypnov

Waste materials which are taken to slag dumps at iron and steel works can be utilized for the manufacture of a large number of valuable building materials.

Of great value for the building industry are the blast-furnace liquid slags which can be made into castings such as pavement plates, curbstones, blocks, facing and flooring plates, architectural pieces, art castings, tubes, tubings for mine props, railroad ties, reinforced plates, window or door lintels and foundation blocks, solid ballast, light porous ballast, as well as blocks and plates from foam slag. In addition, by simple granulation one can make various cements, binding fillers for concrete and plaster, concrete parts, insulating powders, road surface materials (sand, gravel and ballast) from fused slag, and by a complex granulation one can produce slag pumice (thermosite), rock wool, slag wool, etc.

By a special treatment of slags (not for building purposes) one can obtain sulfur, aluminum, fertilizers, as well as medical materials, for instance the granulation effluents can be used for balneological treatment. The properties of the effluents from the granulation are not inferior to the famous Matsesta Waters. The effluent can be utilized for the treatment of a great number of illnesses such as sciatica, rheumatism, nervous disorders and other diseases. As early as 1930, a small clinic for slag-water treatment was set up at the Dnepropetrovsk Plant.

Valuable products can also be obtained from open-hearth slag. Thus, for instance, a large slag-grinding shop producing phosphate-slag fertilizers for agriculture is in operation at the "Azovstal'" Plant. 300,000 tons of this mineral fertilizer will be supplied annually to collective and state farms. The Izhorsk Plant started the production of slag blocks for foundations and walls.

In the Sverdlovsk Region, only one third of the blast-furnace slags are utilized, the remaining bulk is taken to dumps, and in recent years the amount of slag which has been utilized for granulation has even decreased. At the Kuznetsk Metallurgical Combine, the blast-furnace slags are not fully utilized and hundreds of thousands of tons of this valuable raw building material are thrown away.

At present, the Nizhne-Tagil Combine is setting up shops for the production of building blocks, thermosite and other materials. Nevertheless, over 300,000 tons of blast-furance slag is taken to dumps.

A rational utilization of slags at the Chusovsk Plant provides an income of the order of millions of rubles.

The technological process of the production of slag castings consists of degasifying or foaming the liquid slag obtained directly from the furnace, pouring the slag into mold, the crystallization and annealing of the casting; sometimes grinding and polishing is applied.

There are no slag dumps abroad. All slag produced at an iron and steel plant is immediately granulated and transported by conveyors to cement plants which are usually located nearby. Here not only slag blocks and other products, but polished slag blocks for external finishing of buildings, for facing tiles used for internal wall facing, are produced too. Material for building foundations is also made from slag. Liquid slag is poured into the foundation trenches and after it solidifies it forms a monolithic foundation.

Tested processes for improving the structural properties of slag and methods of removing the undesirable impurities from the slag are available. The technological processes of slag utilization, the choice of temperature regimes for crystallization and annealing, the determina-

tion of the rate of cooling the castings after the crystallization is completed, etc, can be developed.

Slag castings have high compressive strength (up to 3750 kg/ cm^2), high abrasive resistance, resistance to shocks, low moisture absorptivity high resistance to frost and a high chemical inertness. Tests have shown that it is possible to obtain cast porous blocks of uniform structure which are light (750 kg/ m^3), strong (compressive strength 50-130 kg/ cm^2), of low thermal conductivity, etc.

In recent years, the Nizhne-Tagil Metallurgical Combine has produced reinforced slag plates, lintels and foundation block of up to three tons in weight. 150 of the lintels 6.5 × 12.0 × 150 cm were used as window lintels in a multistory dwelling house. Experience showed that by replacing reinforced concrete by reinforced slag one saves 150-300 kg of cement, about 0.5 m^3 of sand and 1 m^3 of ballast per cubic meter. Slag concrete has a long life and the iron reinforcement in it does not rust.

The production of foam slags, so called slag pumice, becomes especially important in connection with the extensive development of large-block building techniques. At present, slag blocks are made from granulated slags so that it is possible to obtain a weight of slag concrete equal to 1800 or even 1200 kg/ m^3. The use of pumice as the filler will reduce the weight of slag concrete to 1300-1400 kg/ m^3 and at the same time it will reduce its thermal conductivity by almost half. At the same time, the strength of slag concrete will be adequate for the construction of structural walls of 4-5 story houses. Such walls can be 30-35% thinner than brick walls and their weight half the weight of brick walls.

These, however, are not the only possibilities for slag utilization. Expanded slags can be used for making concrete which, with regard to strength, is suitable for most types of prefabricated panels and beams used in the building industry and, with regard to weight, is one and a half times lighter than ordinary "heavy" concrete made with the use of conventional ballast.

Slag can be used for the production of rock wool and rock felt as well as rock-wool plates – heat resistant insulating material which is also insect proof.

Calculations show that in 1965, during the production of 65-70 million tons of pig iron and 86-91 million tons of steel, one hundred million tons of slag will be obtained; this amount will consist of 85-90 million tons of blast-furnace slag and 16-20 million tons of open-hearth slag. Usually, hot liquid slag constitutes about 70% and the remaining slag is solidified but it can be used for the production of cement, sand, ballast, etc. From this amount of hot liquid slag one can obtain 55.6 million m^3 of lightweight slag concrete, build houses of more than one hundred million m^2 floor area, cast over 140 million m^2 road-surfacing blocks for laying over 20,000 km of motor roads, etc.

With thermosite costing 2 rubles 50 kopecks per m^3 at the Nizhne-Tagil Metallurgical Combine the cost of one ton of pig iron is reduced by 5-10 rubles. If liquid hot slags are utilized for the production of thermosite at all iron and steel plants in the Soviet Union, the annual savings will amount to over 500 million rubles.

The utilization of slags at iron and steel works is an important problem. The establishment of mechanized shops for processing slags at all the iron and steel works and steady supplies of hot liquid slags to slag-casting plants will make it possible to introduce large potential reserves which will provide a substantial additional national income amounting to millions of rubles.

* * *

REMELTING ALLOY-STEEL WASTE INTO CHARGE INGOTS

V. Z. Zykov and G. M. Levinzon

"Vtorchermet" Sverdlovsk Plant

At metal-working plants there is a large amount of waste alloy metals which if utilized properly can contribute to significant savings in the consumption of ferroalloys. The use, however, of shavings at iron and steel plants is difficult because charge consisting of shavings is very light and the shavings received at charge yards of steel-melting shops are usually of diverse chemical composition so that the preparation of the charge for a particular heat becomes difficult.

In 1954, at the "Vtorchermet" Sverdlovsk Plant, the electric steel melting shop consisting of one 1.5 ton electric-arc furnace and one 0.5 ton induction furnace for remelting alloy shavings into charge ingots was put into operation. To increase the output of liquid steel the charge capacity of the arc furnace was increased to 3.5-3.8 tons. The furnace was provided with a transformer of 1000 kw capacity. The high-frequency induction furnace was equipped with a 240 kw-hr generator which supplies two crucibles.

When the alloy shavings are melted it is essential to produce a charge ingot of a definite composition group, i.e., with such a content of alloying elements which would permit the substitution and hence a reduction in the addition of ferroalloys during the production of high-quality steel.

After the chemical composition is tested and the group is established, the shavings are unloaded in an appropriate place in the charging section at the shop.

To reduce the loss of elements to a minimum, one uses the arc furnace for melting chromium, chromium-nickel, and chromium-nickel-molybdenum, shavings and the induction furnace for melting tungsten and vanadium shavings.

Melting shavings in the electric-arc furnace. The process of melting can be divided into three periods: 1) charging of a maximum quantity of shavings into the furnace after the bottom and the banks have been fettled; 2) melting and charging additional shavings; 3) heating metal to the required temperature, and deoxidizing the slag with the object of a partial reduction of the alloying elements.

The remelting of shavings is substantially different from the remelting of lumpy charge. The shavings occupy a considerable volume in the working space of the furnace and have a relatively small weight. Therefore, it is possible to introduce into the furnace only 800 to 1200 kg of shavings during the charging period, and the remaining amount of shavings has to be introduced in three to four batches during the melting period without switching off the furnace. Therefore, the electric regime of the heat is not uniform during the melting period and there are frequent rapid current fluctuations which have a detrimental effect on the operation of the transformer and cause additional load on the motors of the mechanism for the electrode adjustment and on the motors of the automatic equipment.

In 1956, in cooperation with the Uralénergochermet the employees at our shop investigated and established an optimum electric regime for furnace operation. With the transformer operating within the specified capacity limits, the optimum current during the melting of shavings was determined, the possibility of carrying out the melting operation without reactor was investigated, and the most economic conditions for charging the consecutive batches of shavings were selected.

The introduction of the new electric regime made it possible to reduce the time of the heat by 10-15 min and to reduce the electric power consumption by 60-70 kw-hr/ton. However, during the melting of shavings in the electric-arc furnace, considerable time was needed for heating the steel after it had been fully melted. In addition, because of the absence of an oxidizing process, the liquid metal was not mixed, so that the heat was transferred only by the arc and hence the finishing period was rather prolonged. Mixing the bath with stirrers did not produce significant results.

Since the middle of 1956, oxygen had been blown into the bath with the object of speeding up the melting process. At present, oxygen at 8-10 atmos pressure is introduced into the furnace during the melting and finishing periods by means of an iron tube, 1/2 or 3/4 inch in diameter. The blowing lasts for ten minutes and the oxygen consumption amounts to 3 m^3/ ton.

The application of oxygen considerably reduced the time required for heating the metal to the specified temperature; the time was reduced from 40-50 to 15-20 min. In this way, the yield of steel per 1000 kva was increased, the output of the furnace was increased and at the same time electric power consumption was reduced by 80-100 kw-hr/ton. The service life of the lining was not affected.

After the introduction of the above measures the performance of the electric arc furnace improved (Table 1).

As a result of rapid reduction in the number of repairs, the consumption of fire brick, magnesite powder, and other material decreased. The increase in output made it possible to reduce the consumption of graphitized electrodes to 2.5-3 kg/ton.

TABLE 1

Performance of the Electric-Arc Furnace

Year	Output, ton	Yield of steel per 1000 kva	Electric power consumption, kw-hr/ton	Average life of lining, heats	
				walls	roof
1956	9150	24.8	838	574	383
1957	12173	33.4	640	712	702
10 mos. of 1958	10690	35.1	580	850	846

TABLE 2

Performance of the Induction Furnace

Year	Output, ton	Mean productivity ton	Yield of steel per 1000 kva	Average life of the crucible, heats
1955	1504	144	17.3	64
1956	1895	159	19.7	149
1957	1976	165	20.5	160
10 mos. of 1958	1984	198	24.7	255

TABLE 3

Operating Statistics of the Furnace

Year	Output, ton	Output per worker, ton	Cost, rubles per ton of steel
1956	11046	15.6	261
1957	14149	19.5	217
10 mos. of 1958	12673	21.5	185

All this contributed to a considerable lowering in the cost of finished products.

Remelting of shavings in the induction furnace. Operating experience has shown that the charge of the furnace can be increased without affecting the performance of the furnace. The duration of a heat of 550-600 kg does not exceed the duration of a heat of a weight equal to the nominal capacity of the furnace (430 kg).

The crucibles had acid lining; the lining material consisted of two fractions of quartzite: 55-60% of 2 mm fraction and 40-45% of quartz powder. The binding material was 1.5-2.0% of boric acid.

In the course of the operation of the furnace, owing to improvements in the method of resintering the crucible during the whole campaign, a sharp increase in the service life of the crucible (from 50-60 to 270 heats) was attained.

The technology of remelting the shavings in the induction furnace was not known at the Plant and therefore it had to be established in the course of operation. Thus, for instance, one type of shavings did not melt without lumpy material and therefore it was necessary to add 15-20% of lumpy material to the charge, i.e., to use virtually finished product. It was subsequently found that the melting of the shavings depends on the method of charging the first batch of shavings and of ramming the subsequent portions.

The best results were obtained when in the initial period fine shavings mixed with spiral-type shavings were charged and well rammed, as in this way the melting was speeded up considerably. The subsequent portions of the shavings charged into the furnace must be rammed, but the physical condition of the shavings is then of no significance.

By this method the need for the addition of lumpy material was eliminated and the duration of the heat was reduced from 2 hr to 1 hr 25 min-1 hr 30 min.

As a result of mastering the use of the crucible and the technology of melting the shavings, the output of the furnace increased and the economic statistics of its performance improved (Table 2).

Liquid metal is cast into ingots of 180-200 kg weight; the molds have the shape of a truncated trapezoid.

Liquid metal from the arc furnace is collected into a ladle and from the induction furnace it is poured directly into molds arranged four each on a platform which is transported to the furnace by means of a crane. In this way, an intermediate operation – pouring the metal into the ladle – was eliminated and therefore the temperature of the metal could be reduced and the duration of the heat cut by ten minutes. In addition, savings in refractory materials were made and operating conditions were improved.

The technical and economic statistics of furnace operation for the past period are shown in Table 3.

Since the furnaces have been in operation, more than 41,000 tons of alloy material for charging has been supplied to various works producing high quality metals. In terms of the alloying element contained in the total charge, the following quantities were supplied to consumers: 1780 tons of chromium, 1680 tons of nickel, 55 tons of molybdenum, 650 tons of tungsten and 80 tons of vanadium.

* * *

THE TIRLYAN PLATE-ROLLING MILL

V. G. Mel'nichuk

Plant Director

On the decision of the Berg College, May 6, 1759, the industrialists Tserdyshev and Myasnikov were given permission to build a plant on a plot which they bought on the Tirlyan River. In addition, they were given the right to fell wood for timber over an area of up to 20 verst * distance from the plant, depending on the density and the quality of the wood.

Initially, they started to build a sawmill on the Tirlyan River but as the river became shallower the expediency of building the mill at this location became doubtful. They found a suitable site for building a works on the Bela River and on July 18, 1762, they applied to the Berg College for permission to transfer the works from the Tirlyan River to the Bela River about 30 versts south. They obtained permission and at the same time it was decided to change the name of the plant form the Tirlyan plant to the Bela-Reka plant.

Nevertheless, the construction of the iron plant on the Tirlyan River was continued, although it was then renamed the Bela-Reka Plant together with the other Plants on the Bel River. The Tirlyan Plant was developed and run as an independent establishment.

Up to 1773, the Plant had only one blast furnace which was supplied with ore by horse carts from the ore mine located 15 km north of Tirlyan as well as from the Magnitna Mountain. Charcoal was used as fuel and was produced from the neighboring woods. The air blowing machine was water driven.

In the Plant yards a large amount of small pig-iron pieces and pig-iron scrap accumulated and in 1771-1773 several bloomeries were built for the conversion of this pig iron. One more water-driven air-blowing machine was built to supply these furnaces with air.

In 1778, the construction of a mill for rolling the bloomery iron into light sections and roofing sheets was started. The mill was completed in 1785 and production was started.

After 1803, roofing sheets from the Tirlyan Plant, with the trade mark "Staryi sobol'," were advertised as one of the best roofing materials for industrial and dwelling houses and captured the market owing to the low price compared with products from other Ural works.

At the end of the 18th and at the beginning of the 19th century, the Plant began to undergo gradual changes. Some of the machines which had been driven by water wheels were converted to steam-driven machines. But the metallurgical aspects of the works operation remained almost unchanged until the end of the 19th century.

At the beginning of the 1870's the Pashkov brothers, the owners of the Plant, were declared bankrupt. The management of the Pashkov Plant was temporarily taken over by the State Administration which operated from Moscow.

In 1874 a wealthy German industrialist and businessman, Hugo Vogau, founded, together with Pashkov, the "Pashkov Bela-Reka Iron Plant Joint-Stock Company" which bought the Bela-Reka and Tirlyan Plant together with the attached land from the State Administration. Thus the German shareholders became the actual owners of the Tirlyan Plant and administered it until the October Revolution. The Pashkov brothers hardly visited the Tirlyan Plant, and all they were interested it was to squeeze as much profit as possible out of it. In 1872, some of the bloomeries were shut down, and eight puddling furnaces for the conversion of pig iron into wrought iron and steel were built.

In 1874, the Tirlyan Plant was partly reequipped for the production of roofing iron. A two-stand sheet-billet mill driven by a steam engine was built. At the end of 1874, a four-stand sheet-rolling mill was installed. When they were rolled, the sheets were covered with fine charcoal dust and then a pile of rolled sheets was again heated in the furnace and worked under a hammer whereby the scale became embedded in the metal sheet and formed a gloss surface which was resistant to corrosion. Roofing made of these sheets would last for decades without being painted.

For the finishing operations on the roofing sheets there were four tilt hammers and four shears which were driven by a water wheel.

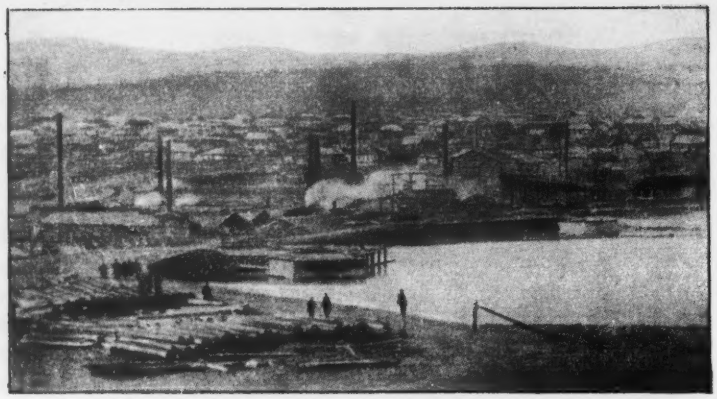
Four the final dressing and packing of sheets, a separate building was erected in 1882; it has been preserved until now and is used as a storage for building materials.

At the end of the 19th century, the throughput capacity of the bloomeries, puddling furnaces and rolling mills were by far higher than the capacity of the blast furnace. Therefore, a second blast furnace with steam-driven air blower was built in 1890.

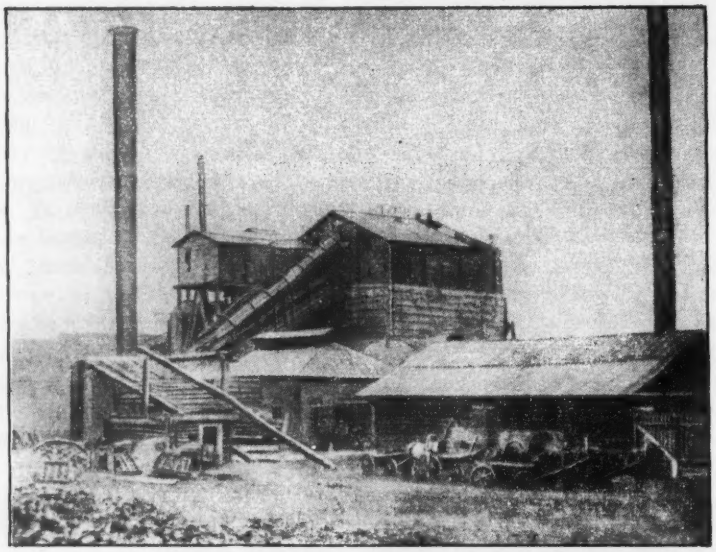
In 1895, all the bloomeries were removed and the section-rolling equipment was pulled down. In its place a powerful strip-cutting hydraulic press, shears, and a new steam engine were installed. In 1897, the erection of a three-stand sheet-rolling mill driven by a steam engine of 1200 hp,which was also driving the sheet mill, was completed.

From 1903 to 1909, the modernization of the Plant was continued with the object of increasing the output of sheet; the blast-furnace production was completely shut-down, and the sheet-billet mill, together with all its

*1 verst=1066.8 m.



General view of the Plant in 1884.



The blast furnace of the Plant in 1875.

auxiliary equipment,was transferred to the Bela-Reka Plant.

By the end of 1910, the sheet-rolling and sheet-finishing shops were completed. In 1913, a power station with a capacity of 1700 kw was built, and in 1914 electric motors were installed; a 15 hp motor for mill No. 1 and a 950 hp motor for mill No. 2.

In November, 1917, as soon as the victory in the October Revolution became known, the workers organized guards at the Plant and took over the control of production. By the order of the Military Revolutionary Council all the management including the director, Kanenberg, were removed from their posts and the administration and management of the Plant was entrusted to A. F. Oboimov a representative of the Military Revolutionary Council.

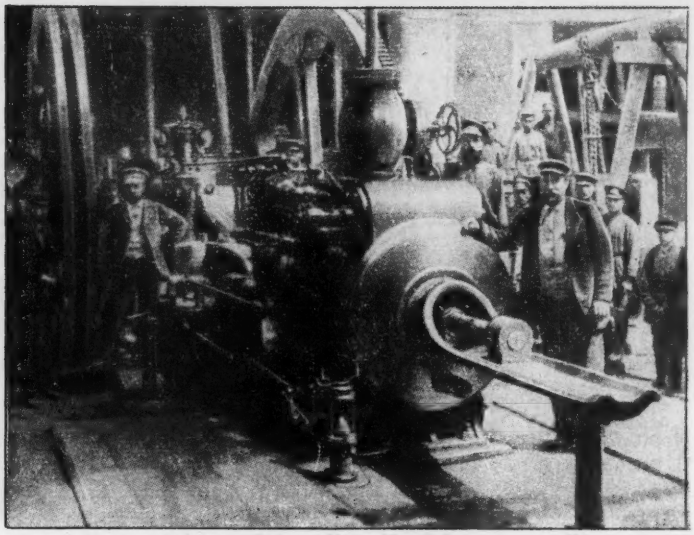
The Military Revolutionary Council assisted in establishing normal operation at the Plant and in organizing supplies of the necessary materials.

In the summer of 1918, the Tirlyan Plant was occupied by White-Russian forces and had to be shut down because all the workers went away with the Bela-Reka Partisan Army.

In July, 1919, the Plant was liberated by the Red Army. Former employees began to arrive home after the Civil War and, first of all, set about restarting the Plant.

On July 15, 1919, a Plant Committee under the chairmanship of P. K. Lokotskov was set up. A Board of Management under the chairmanship of A. Ya. Ogloblin, a member of the Communist Party of the Soviet Union since 1902, was appointed.

The Board,which was made up of leading workers and specialists devoted to the Revolution, started work on restoring the plant and preparing it for normal operation. On July 25, 1919, the power station was put into operation and soon the sheet-rolling mill was started up. The



The first steam-engine installed at the rolling mill.

workers made incredible efforts to produce the materials needed by the state while there was general disorder, hunger and epidemics. By the beginning of May, 1921, the reserve stocks of sheet billets and fuel were depleted and the Plant had to shut down.

Owing to the tireless efforts of the Plant committee and the workers, the plant was started again by September, 1921. Up to 1930, the Plant was producing only roofing sheets rolled by the old Ural method.

Between 1931 and 1934, the Plant was reequipped for rolling and finishing structural and passivated steel. The old stands with cast frames for rolling roofing iron were removed, and new stands of a higher capacity with steel housings and rolls of 700 mm diameter were installed. The rolling mill was equipped with doublers and the old Ural method was replaced by a better and more efficient European method of rolling thin sheets.

In the course of the modernization, a pickling shop with three pickling machines and two bridge cranes for the removal of scale was built. A continuous tunnel furnace was built at the sheet-finishing section.

During the Second World War the Plant switched to the production of steel products necessary for defense – high-carbon structural plate of various dimensions. In the postwar years the production of thin passivated sheet increased considerably.

In the first half of 1947, the Plant introduced the production of electrotechnical steel sheet – a new material – which at present constitutes 85-90% of the total output of steel sheet. The increase in the output of electrotechnical sheet was accompanied by an increased mechanization, an improvement in technology and the organization of production. In the postwar years the rolling mill was equipped with low-type doublers which considerably facilitate the bending of the strip into piles; with pneumatic hoists which make the charging of the sheet piles into the furnace much easier; and with conveyors for the mechanical transportation of heated sheet billets and piles from the furnace to the mill. In addition, five reheating furnaces were modernized and an underground ventilation system for the working places was built. The height of the building of the rolling mill was increased by 5 m and a bridge crane of 15 ton lifting capacity was installed above the stands in the bay. The electric motors for the mill drive were replaced. All the stands were equipped with semiautomatic screwdown equipment.

Working conditions at the auxiliary sections directly adjoining the rolling mills were also made much easier. A covered mechanized store of 1500 ton storage capacity for sheet billets was built and equipped with a 5 ton bridge crane. The roll-grinding shop was greatly extended and was provided with a new automatic roll-grinding machine. In the cutting and packing section, a bridge crane was installed and a two-stand dressing shop was put into operation and an opening machine for pulling the sheets apart was installed.

A new building for the pickling shop was built in the sheet-finishing section; a second bridge crane and a second continuous furnace for the heat-treatment of sheets were installed in the heat-treatment section; a new building for sorting and packing was built and was equipped with a bridge crane and a magnetic disc for loading finished products onto flat railroad cars.

In 1945, the Plant started the production of galvanized vessels.

Between 1945 and 1955, a separate bay for pickling and galvanizing assembled parts was built next to the building of the machine shop of the general purpose section. The range of galvanized products has increased every year. At present, the shop produces riveted galvan-

Leading mill operators of the Plant (from left to right): standing : G. P. Shagaev, M. Ya. Afletunov, S. P. Knyazev, and F. G. Khuzhin; sitting: Kh. G. Sunagatov, A. S. Urtsev, Ya. A. Chertikhin, and Kh. B. Bagaytdinov.

A group of old workers at the Plant (from left right): standing: S. E. Medvedkov, N. F. Mart'yanova, and V. S. Lepikhin; sitting: M. M. Gorbunov, S. S. Urtsev, and I. I. Saitburkhanov.

ized articles of all types defined by standard specifications. In recent years, the general purpose shop has considerably expanded the processing of waste material from sheet rolling production into roofing sheets. In 1958, the production of large size roofing sheets was started. Some extensive changes, including the change to liquid fuel for all shops, a complete modernization of the electric power supply, the installation of two more bridge cranes, the installation of equipment for electric heating of sheet-rolling rolls, the installation of a boiler, etc., have been planned for 1959.

The Tirlyan workers who were brought up in the best revolutionary tradition – the traditions of the heroic deeds of the Civil War – continue to work with dedication on increasing the industrial power of our country.

The personnel has every right to be proud of our old workers who have toiled selflessly all their lives in the

most responsible sections of production. The seven oldest workers were awarded the Order of Lenin.

Between 1949 and 1958, 528 workers were awarded orders and medals for selfless and dedicated efforts, and 134 of them received the Order of Lenin. Inspired by the resolutions of the Twenty-First Congress of the Communist Party of the Soviet Union, the personnel of the Plant is making every effort to fulfill the Seven-Year Plan ahead of schedule.

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THE USE OF OXYGEN* IN STEELMAKING

In recent years, various processes of steel melting with the use of oxygen have been extensively employed.

The L-D process employs a solid bottom converter equipped with a nozzle for feeding technically pure oxygen through the converter throat. The name of the process is derived from the initial letters of the Austrian steel plant in Lintz and Donavitz, where this process was first introduced. At Oberhausen (Federal German Republic) a rotary furnace is used for steel melting. Hence, the process is called the Rotor process. At the Domnarvet Plant in Sweden, drum-type furnaces are used and the process is called the Kaldo process (from the name of the inventor, Kaling, and the name of the Plant, Domnarvet). The main operating statistics of these three processes are shown in the Table.

A characteristic feature of the L-D process is the early formation of the basic oxidizing slag so that the decarbonizing and dephosphorizing of the steel can proceed simultaneously. Therefore, there is no need for the after blow, characteristic for the Thomas process; the L-D process can be stopped when the steel attains the required carbon content. A higher thermal efficiency as compared with the Thomas process makes the use of the return scrap possible. Compared with the open hearth shop of the same output, the load of the soaking pits of the rolling mill is smaller and therefore the interval between the consecutive batches of ingots delivered from the steel-melting shop to the steel-rolling shop is reduced.

Steel made by the L-D process and the open-hearth process contains approximately the same amount of oxygen and nitrogen. The capital cost of the L-D process amounts to about 60% of the cost required for open-hearth production of the same quantity of steel.

The main difficulties of the L-D process are the following. This process is difficult to control and therefore it is thought that it is suitable only for the production of low- and medium-carbon steels. However, a great deal of experience on the production of railroad steel and chromium steels made by the L-D process has been accumulated in Austria, and reliable methods for stopping the blowing at the moment when the steel has the required carbon content have been developed. A repeated slag removal and a rapid determination of the steel composition in the course of melting can be used as a means for obtaining the steel of the required grade. This provides a basis for a mass production of low- and medium-carbon, killed, rimmed, and semikilled steels.

It is considered that the L-D process is suitable for pig iron which contains not more than 0.3% phosphorus. To use this method for the treatment of most of the pig irons which are available in Great Britain, it is proposed to apply double slagging in the course of melting and retain the second slag in the converter for the next heat. An addition of ore and fluxing agents cools the bath and assists in an early formation of the slag.

When pig irons of high silicon content are processed, it is found that the slag tends to foam and overflow through the throat of the converter. For the elimination of this phenomenon it is proposed to modify the shape of the converter and to employ a preliminary removal of silicon from the pig iron.

At the Domnarvet steelworks in Sweden, a rotary Kaldodrum of 26 ton capacity was installed at the converter shop in May, 1956. The drum can be used for processing pig iron of any chemical composition. The lining of the drum consists of four layers: the outside layer is made of insulating brick; the next two layers are made of magnesite and tarred dolomite brick respectively and then follows a rammed layer of tarred dolomite. The speed of the drum is 30 rpm; it can be tilted and set in various positions for charging the pig iron, ore and lime, for blowing and for tapping. The oxygen lance is introduced into the metal through the charging opening. So that the lining has a longer service life, the blowing is carried out when the drum is in an inclined position; the waste gases leave through the charging opening. Slag is made three times if the pig iron contains 1.8% phosphorus. For thickening the last slag, lime is charged into the drum and the slag is left for the next heat. In the Kaldo drum as well as in the open hearth furnace, unlike in the Thomas process, reactions take place between the metal and the slag and therefore phosphorus is removed before the charge is decarbonized. It is noted that the processes in the Kaldo drum are nearer to the equilibrium process than in any other plant for making steel with the use of oxygen. This is explained by the favorable effect of the rotary movement of the drum on the mixing of the bath. By controlling the speed of the drum and the rate of oxygen supply, one can control the carbon loss and the dephosphorization process.

The combustion of a considerable portion of carbon monoxide, which is evolved in the drum, increases the thermal efficiency of the process and therefore it is possible to use scrap or ore for cooling the metal. The method which has been developed for controlling the process is based on the dependence of the temperature of waste gases leaving the drum on the amount of carbon monoxide which is burnt inside the drum, and it permits the selection of the required drum speed and the oxygen supply rate.

The Rotor process is used in the Federal German Republic for the preliminary treatment of blast-furnace pig-iron prior to the open-hearth process. It should be noted that this process can be used for the direct production of

*Iron and Steel 31, 499-503 (1958).

Process Data

Item	Process		
	L-D	Kaldo	Rotary
Capacity of the melting vessel, m	35	26	60
Length or depth of vessel, m	4.39	3.50	14.61
Diameter of the vessel, m:			
inside	2.8	2.1	2.4
outside	3.9	3.5	3.7
Thickness of the lining, mm	400	500	600
Speed, rpm	No rotation	0—30	0—0.5
Temperature of the steel at the time of pouring, °C	1590	1610	1580
Duration of the process, min	34	80	120
Duration of the blowing period, min	18	40	55
Consumption, in%wt. of ingot prod.			
scrap	12	—	—
lime	6	11	12
scale	1		
Oxygen consumption, m^3	55.0	67.9	44.7
Refractories consumption, kg/m	5.0	12.2	49.9
Oxygen pressure, atmos	7—15	3	4
Ingot yield, %	85—90	89	91
Purity of oxygen, %	99.5	96	Primary 99.5 Secondary 70
Rate of carbon loss, % C/min	0.18—0.20	0.07—0.09	0.05—0.07
Life of oxygen nozzle, heats	1200	—	300
Life of lining, heats	275	55	50
Time taken for replacing the lining, days, (24 hr)	3	3—4	5

• The difference in the oxygen consumption is due to the fact that in the L-D process one uses open-hearth pig irons, and in the Kaldo and the rotary process — phosphorus-containing pig iron. (Editor's note).

steel from blast-furnace pig-iron of any chemical composition. The outer layer of the rotary furnace lining is made of magnesite brick and the rammed internal layer of tarred dolomite; the slag strongly attacks the end walls of the furnace and they have to be made of chrome-magnesite brick. The wear of the furnace lining is reduced when it is washed with liquid metal during furnace rotation (0.1-0.5 rpm).

The rotary furnace can be tilted up to an angle of 6.5°C. Only one slag is made in the furnace if the process is limited by the reduction in the silicon content in pig iron (a semiproduct is obtained); if, however, one wants to obtain the steel directly, then after the first slag which contains approximately 5% Fe and 20% P_2O_5 (at the same time the metal contains approximately 2% C and 0.15 P) is run off, the second slag,which is thickened with lime and retained in the furnace for the next heat, is made. A rapid formation of reactive slag and a high temperature in the furnace are favorable for the simultaneous dephosphorization and decarbonization processes. The process can be stopped when the steel attains the required carbon content. The use of a second oxygen lance for an additional supply of oxygen assists in a more efficient combustion of the carbon monoxide inside the furnace; there is a possibility of reducing a substantial amount of iron in the ore charged into the furnace. The process is controlled automatically according to the content of carbon monoxide in the furnace atmosphere.

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V. N. Bronshtein. Reducing Defective Products in Steelmaking Moscow, Metallurgizdat, 1959, 141 pages.

V. N. Bronshtein's book, which is due to appear shortly, is based on the operating experience of steel plants and on literary sources, and contains an analysis of the main causes of defective products in steelmaking. The first chapter of the book contains the main GOST specifications with respect to the quality of the steel and gives the classification of steel defects. The effect of the technology of steel melting on the quality of the steel is discussed in the second chapter. A detailed analysis is given of the effect of the quality of raw materials, methods of charging, conditions of the furnace, the thermal regime of the melting process, and other factors, on the defects of steel with respect to its chemical composition and surface condition.

Chapter III, called "The Ingot and the Mold," deals with the main theoretical principles of the steel solidification and the defects of ingots. The design of molds and the preparation of molds for pouring are described. The fourth chapter is devoted to the regime of steel pouring: temperature conditions, procedure of filling the hot top, thermal insulation of the hot top, etc. The effect of refractories on the contamination of steel with inclusions and the effect of the regime of cooling on the quality of the ingot are discussed.

The chapter on the preparation of ingots for rolling contains the description of the methods of dressing the ingot surface.

The book is written in nontechnical language and will undoubtedly be of great interest to foremen and skilled workers at iron and steel plant. A. G.

V. Lyuiken. The Preparation of Raw Materials for the Blast-Furnace Process. Translated from the German by I.S. Gofman, Editor Eng. Ya.I. Dashevskii, Moscow, Metallurgizdat, 1959, 413 pages.

The recently published book by Professor V. Lyuiken deals with chief methods of preparation of ores and fluxes for the blast-furnace process. After discussing the main requirements with regard to the charge for smelting in the blast furnace, the author passes to the description of the charge materials – iron ores, manganese ores and limestone – and the methods of their evaluation. In this part of the book, as well as in other chapters, the economics of the preparation of ores is stressed.

The author analyzes in detail methods of preparing the ore for smelting-crushing, screening, beneficiation of iron ores, and the oxidizing and magnetizing roastings. This part of the book is extensively illustrated with a large number of diagrams and drawings. There is also a description of the production of sponge-iron and some complex methods of ore beneficiation.

In the chapter devoted to the methods of charge agglomeration, the author describes the technology of briquetting and known methods of sintering iron ores. An account of coke-iron production is given here.

The author discusses the economic advantages of the preparation of the charge for smelting and the effect of various factors on the cost of pig iron. A short chapter is devoted to coke production. At the end of the book, there is a description of some ore-preparation plants in use abroad.

V. Lyuiken's book is intended for technical personnel of metallurgical establishments and research institutes. It may be found useful by university students.

A. G.

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosénergoizdat	State Power Engr. Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LÉIIZhT	Leningrad Power Inst. of Railroad Engineering
LÉT	Leningrad Elec. Engr. School
LÉTI	Leningrad Electrotechnical Inst.
LÉTIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MÉP	Ministry of Electrotechnical Industry
MÉS	Ministry of Electrical Power Plants
MÉSÉP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTi	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NIIZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOÉ	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIÉL	Central Scientific Research Elec. Engr. Lab.
TsNIÉL-MÉS	Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIÉSKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZÉI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us - Publisher.